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Saving and restoring
Louisiana's coastal wetlands

ON THE COVER: This is 2-year-old sea oats on Constance Beach in Cameron Parish, La. The Constance Beach field trials are part of a long-term sea oats study being conducted by the LSU AgCenter to track plant vigor and seed production among northern Gulf of Mexico and Atlantic Coast sea oats populations. Photo by Michael D. Materne

Youth Wetlands Week

Training future leaders to save America's treasure

The LSU AgCenter took a bold step this year by inaugurating a Youth Wetlands Week – and it was a huge success.

During the week of April 16-20, more than 20,000 students – grades 7 through 12 – in more than 150 schools became aware of the Louisiana land loss crisis and what can be done about it. Some had the opportunity to plant soil-saving plants in nearby wetlands. In the process the students learned valuable science lessons.

"We plan to sponsor a Youth Wetlands Week every April for a long time to come," said Carrie Castille, coordinator of environmental education for the LSU AgCenter and the principal architect of the event.

Photo by Bruce Schultz

Iowa High School ninth-grader Jordan Pickett pours silty water into a mixture of sand, rock and vegetation to simulate the filtering effects of wetlands. The educational activity at Iowa was just one of many across the state April 16-20 as the LSU AgCenter orchestrated Youth Wetlands Week.

At Iowa High School in Calcasieu Parish, 4-H leader Sharon Nabours gave a lesson on the role wetlands play in filtering sediment and other material before they reach waterways and the Gulf of Mexico. Nabours used plastic soft drink bottles cut in half for students to make models of the surface of a wetlands area, using any combination of a coffee filter, rocks, sand and grass.

Iowa High School agriculture teacher Bill Thompson said the lesson helped with what he is trying to teach his students.

"We touch on environmental issues, but with everything we have to cover during the year it's difficult to get in depth," he said. "I'm planning to use this lesson in the future."

In Sandra Givens' Mt. Hermon High School science class in Washington Parish, the students constructed "wetlands in a pan," complete with coastlines and barrier islands.

Shane Kraft, the 7th grade life science teacher at Pontchatoula Junior High School, took her students to Turtle Cove to plant some marsh plants.

Funding for this massive effort comes from a $1.5 million, three-year grant, ad-

(Continued on page 39)

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Potential growth seen for biofuels from nonfood crops

Louisiana and its neighboring states have the potential to raise nonfood crops for biofuels because they have suitable available land and a long growing season, said Michael Blazier, assistant professor of forestry at the LSU AgCenter's Hill Farm Research Station near Homer.

Speaking at the Ark-La-Tex Forestry Field Tour on March 29, 2007, at the states, Blazier said switchgrass, Indian grass and big bluestem grass are three varieties he has planted among pine trees on the research station. He's evaluating them as sources of biomass for the production of ethanol and how they grow around and among a thinned stand of loblolly pine trees.

He said switchgrass could be a good choice because it's a summer perennial native to Louisiana, requires low amounts of herbicide and fertilizer to get established, requires little or no management, is tolerant to both drought and floods, grows well in partial shade and produces high yields.

"Louisiana has the diversity, climate and infrastructure for biofuels," Blazier said. ■ **Rick Bogren**

Master Farmer training offered in new format

Because of the success of the Louisiana Master Farmer Program, AgCenter professionals extended the training to even more farmers by offering it in a different format for the first time this spring.

The introductory sessions had been offered in a traditional classroom setting for each group of participants – thus limiting the number of people who could be involved at any given time. But the latest effort in early March used the AgCenter's distance education network, which allowed participants in several locations to interact with instructors simultaneously

"More than 2,300 hundred farmers have participated in the program since its inception six years ago," said AgCenter associate Donna Morgan, who helps to coordinate the Master Farmer Program.

The Louisiana Master Farmer program is an environmental education program designed to help farmers and ranchers identify and adopt best management practices that will help them address environmental concerns, such as water quality, while also maximizing their potential productivity.

This latest initiative means the educational benefits offered by the model program can be provided to new farmers as well as those who were unable to attend the first meetings. ■ **John Chaney**

Students pitch in for coastal restoration

What once were pastures now are wetlands – with water where cattle used to graze beside a levee near Pointe Aux Chenes. Seventh-grade student at Montegut Middle School planted smooth cordgrass near the water's edge at the foot of the levee.

The wetlands planting field trip on April 17 was under the direction of seventh-grade science teacher Cally Chauvin and LSU AgCenter fisheries agent David Bourgeois.

"I appreciate you coming here and helping with this program," Bourgeois said to the students as they prepared to plant the marsh grass. "You're part of our family."

The smooth cordgrass was provided by the AgCenter and produced at the LSU AgCenter's Rice Research Station in Crowley.

The activity was part of the Coastal Roots program, a partnership that includes the LSU AgCenter, the Louisiana Sea Grant College program, the LSU Department of Education and various local government agencies. The Pointe Aux Chenes activity was cosponsored by the Terrebonne Levee District and the Barataria-Terrebonne National Estuary Program.

In addition to the support of the participating partners, Chauvin was able to obtain a $1,000 field trip grant from Target Corp. to fund the local activity.

"This is great. This is wonderful," she said of the students' participation. "This is their home. We're going to plant this parish because we're going to be here a while."

Bourgeois said the students' attitudes toward their environment have been enhanced by their participation in the Coastal Roots program.

"These students realize the potential of this project," he said. "And they're doing it in their own backyards. The most value is the stewardship they're learning. They can learn it's up to them to preserve this and protect their own homes." ■ **Rick Bogren**

Fifth graders learn wetland facts at Red River Station

A group of 21 Oil City Elementary Magnet School fifth graders learned some new words as they toured a wetland project at the LSU AgCenter's Red River Research Station in Bossier City on April 26, 2007.

Photo by Mark Claesgens

Justin Guy and Frankie Foret, seventh grade students at Montegut Middle School, plant smooth cordgrass at the foot of the levee at Pointe Aux Chenes in April. The students were participating in the LSU AgCenter's Coastal Roots program, which works with teachers to help students learn about coastal erosion while they help stem the loss of Louisiana wetlands.

Global positioning satellites, buoys, Google Earth, elevation and topographical were just some of the terminology used in the lessons for science teacher Cindy Kilpatrick's group.

The Constructed Wetland Project is a research effort to see if natural biological and chemical processes can be used to help reduce water pollution.

"The goal of this project is to show how using natural resources, such as a wetland, can improve the water quality of runoff coming off agricultural land," said Eddie Millhollon, LSU AgCenter researcher at the station.

Nonpoint-source pollutants – water pollution that comes from undetermined sources – have been cited as a suspected cause of much of the impairment of waterways in the Red River Basin, Millhollon said. He said the project has shown significant improvement in water quality, through sampling water at various points along the path of the system, from the point where runoff enters the wetland to the point where it leaves.

Rain triggers a series of events that puts an automated water sampling machine into action. A solar panel powers the sampling machine. The sample is sent to a lab to determine water quality.

The group began their lesson in the conference room at the station, viewing a large map and a model of the project built by Russell Anderson, research associate.

They then visited both the shallow and deep pools of the wetland. The three-foot shallow pool is a manmade swamp with vegetation that can facilitate sediment build-up and filter fertilizers out of the water, Millhollon said. The 9-foot deep pond provides additional nutrient reduction in an environment where anaerobic bacteria break down pesticides.

Fifth grader Robby Null said seeing the two different pools was his favorite part of the day. He even caught a glimpse of a snake in the water.

The children appeared amazed that fish were in the manmade pool, but Millhollon explained that they likely got there from birds with eggs attached to their feet.

Runoff from fertilizer used to makes things grow can cause algae to expand and take oxygen out of the water that fish need to survive, Millhollon said. The wetland project keeps fertilizer from getting into Flat River, which runs into Red River.

■ **Mary Ann Van Osdell**

Brown widow spiders show up in Louisiana

The brown widow spider is becoming more common in Louisiana and a cause for concern, according to Dennis Ring, LSU AgCenter entomologist.

Generally found in tropical areas, the brown widow spider is closely related to the black widow spider and is poisonous. Experts say the spider ranges in color from gray or tan to dark brown and may reach 1 inch to 1½ inches long.

Like its better-known black widow cousin, the brown widow spider has a yellow-to-orange hourglass marking on the underside of its abdomen. It also has black and white marks on the top of the abdomen and often has dark bands on its legs.

"Its venom is more toxic than the black widow's," Ring said. "But it doesn't put out as much venom in its bite."

Ring said the brown widow spider is most often found in areas that haven't been disturbed, such as brush piles, wood piles and areas where hurricane debris has accumulated. They also can show up in crawl spaces, under chairs, in garbage can handles and under flower pots, eaves and porch railings.

"These spiders are shy and are less likely than black widows to bite humans," Ring said. "Nevertheless, they can bite when they come in contact with a person's skin."

Ring suggests wearing gloves, long-sleeved shirts and long pants when working outdoors, especially in areas that don't get a lot of human activity.

■ **Rick Bogren**

Experts help sugarcane growers with hurricane losses

Work by the LSU AgCenter was instrumental in a U.S. Department of Agriculture program that has compensated sugarcane producers with $40 million for losses caused by hurricanes Rita and Katrina.

Sugarcane specialist Ben Legendre said payments were recently distributed, and he said several individuals in the LSU AgCenter and other agencies worked to provide information that helped farmers.

Part of the compensation program was dedicated to losses from Hurricane Rita's storm surge that flooded sugarcane fields. LSU AgCenter scientists, using geographic information systems technology, produced digital maps of the area inundated in seven coastal parishes. These were provided to the federal Farm Service Agency to determine which fields were flooded and to calculate affected acreage so sugarcane farmers could receive payments for their losses.

Willie Cooper, state director of the FSA, said the interagency cooperation involved in administering the program is not unusual in the state.

"Louisiana has the best working relationship of any state in the country when it comes to the agriculture industry – both governmental and non-governmental entities," Cooper said.

Paul Coreil, vice chancellor for the LSU AgCenter's Extension Service, said the mapping work "is just another example of putting research to work on the ground to help farmers and communities recover from storm damage from Hurricane Rita."

■ **Bruce Schultz**

Saving Louisiana's Coastal Wetlands

Klancy Shope from Calcasieu Parish at a recent Marsh Maneuvers camp. The LSU AgCenter involves young people in coastal restoration activities including Marsh Maneuvers (page 26)

The LSU AgCenter brings its considerable expertise in plant breeding and other traditional areas of research to address wetland loss.

Since the 1930s, about 1,900 square miles, or almost 1 million acres, of wetlands along Louisiana's coast have been lost. This loss continues at the rate of about 30 square miles per year. Factors that cause this relentless erosion of one of America's most valuable resources include the Mississippi River levee system that prevents sediments and nutrients from replenishing adjacent marshes, subsidence from compaction and sinking of soft marsh soils, and saltwater intrusion that kills vegetation.

The ramifications of this land loss are huge – not only for Louisiana but for the nation. Here are some facts from the Council for a Better Louisiana:

- Thirty percent of all U.S. coastal marsh is in Louisiana.
- Ninety percent of the coastal wetland loss in the lower 48 states occurs in Louisiana.
- Ninety-five percent of marine species in the Gulf of Mexico spend all or part of their lifecycle in Louisiana wetlands.
- Louisiana's coastal wetland provides habitat for more than 5 million waterfowl and is home to more than 70 rare, threatened and endangered species and America's largest wintering habitat for migratory waterfowl and songbirds.
- More than 30 percent of the nation's commercial fishery catch comes from Louisiana coastal areas.
- More than 25 percent of oil and gas consumed in the nation travels through Louisiana wetlands.

One line of defense to prevent further land loss is to improve native marsh plants – to help them proliferate and do what they have done for thousands of years – hold onto land and keep it from washing out to sea. And that is where the LSU AgCenter plays a significant role. Nearly 10 years ago, LSU AgCenter researchers began a concerted effort to do for wetland plants what they have been doing for agricultural crops for decades – develop new varieties and more efficient management techniques.

"We use our expertise in plant breeding to develop plants and improve coastal habitats with the goals of restoration and reclamation," said David Boethel, LSU AgCenter vice chancellor and director of the Louisiana Agricultural Experiment Station.

The principal plant targeted has been Spartina alterniflora, known as smooth cordgrass. This plant tolerates a wide range of salinity and can readily be produced in freshwater ponds. It is an ideal species for coastal reclamation work because of its stress tolerance and rapid growth. A single plant can grow to a clump of several feet in diameter within a year. It spreads underground and its dense canopy provides a significant buffer against wave energy. It grows parallel to the shore in water up to 18 inches deep.

"Spartina is very productive and very adaptable," said Steve Harrison, plant breeder in the School of Plant, Environmental & Soil Sciences.

Other plants being studied include sea oats and bulwhip, which have some of the same characteristics as smooth cordgrass. See the article on sea oats, page 20, and on plant diversity, page 21.

The challenge in trying to populate barren areas with these plants is that they are not good at producing seed – unlike agricultural crops. And coastal restora-

Photo by Bruce Schultz

and Coastal Roots (page 13). In addition, the LSU AgCenter has inaugurated a Youth Wetlands Week for schools, which will occur every April (page 2).

tion requires massive quantities of seed – good quality, viable seed.

AgCenter researchers have several projects under way to solve this problem. In the breeding program they select individual plants that demonstrate superior seed characteristics and use techniques such as selective crossing and tissue culture to develop improved lines. It is likely the AgCenter will release three new varieties of coastal plants later in 2007 – a smooth cordgrass line, a bulwhip and a sea oats variety.

Other problems with smooth cordgrass seed include dormancy and a tendency to die when dry. An AgCenter research project focuses on understanding these two traits and using this information to allow large-scale stand establishment of smooth cordgrass from seeds (page 25).

Another research team is working on diseases that affect smooth cordgrass on page 24. The severe brown marsh dieback along the coast in 2000 was caused in part by disease. Read the article about how researchers used small dredge sediment enrichment to restore brown marsh sites on page 8.

Acceleration of plant production requires fast seeding and efficient harvesting. AgCenter scientists have been successful in adapting aerial seeding – as is done in rice production, for example – for smooth cordgrass plots. Harvesting, however, still must be done by hand. But the plant breeders and engineers are trying to adapt some type of harvester that can maneuver on soft soil and mechanically remove the seeds.

Much of the initial research on coastal plants was conducted with the U.S. Department of Agriculture's Natural Resources Conservation Service, and collaboration with this agency continues. The NRCS operates a 93-acre plant materials research center at Golden Meadow, which is about 20 miles southeast of Houma.

The AgCenter conducts coastal plants research in the Department of Plant Pathology & Crop Physiology, the School of Plant, Environmental & Soil Sciences and at the Rice Research Station in Crowley. Other units that contribute include the Department of Biological & Agricultural Engineering and the Department of Agricultural Economics & Agribusiness.

Scientists have research plots at the Central Research Station south of the LSU campus. Additional research areas and greenhouses will be constructed as part of the master plan for renovations and expansion at the Central Station and Aquaculture Research Station, also south of campus.

Much of this research activity will move over the next couple of years to the Coastal Area Research Station, formerly known as the Citrus Research Station. This is the AgCenter's station in Plaquemines Parish – a parish that extends the farthest out into the Gulf of Mexico. Hurricane Katrina destroyed much of the station in 2005. The master plan for the new station includes new facilities and five ponds for plant research. Read more about the new station on page 39.

"We had already planned to make this change before Katrina," Boethel said. "The hurricane's destruction accelerated our plans. The focus of the research conducted at the site will change, but our commitment to that region of the state will remain. "

Louisiana's wetlands are not only essential to the ecosystem but also to national security. Saving and restoring them requires many different entities bringing together their expertise and building upon each other's knowledge. The LSU AgCenter has committed significant resources to this effort and has made important contributions – and will continue to do so well into the future. The articles in this magazine provide a look at some of the accomplishments.

■ **Linda Foster Benedict**

Factors controlling

the restoration of brown marsh sites *with dredge sediment enrichment*

Michael D. Materne, Irving A. Mendelssohn, Angela Schrift, Ashley Wilson and Sheila Rohwer

Wetland deterioration is a significant environmental problem in coastal Louisiana. Although natural and human-induced factors have both been cited as causing wetland loss, many of these effects are mediated through one common agent: sediment availability. Therefore, a sound approach for reducing wetland loss and restoring deteriorated wetlands is the addition of sediment to increase marsh elevations to a level that will support wetland plants.

Although a number of innovative ideas—spray dredging, sediment transport through abandoned oil and gas pipelines, beneficial-use dredging—appear promising, a major limitation to the use of dredged material is the limited understanding of how different depths of added sediment affect the structure and function of wetlands. Too little sediment may have no beneficial effect while too much sediment may detrimentally modify the vegetative dynamics and ecosystem processes essential for the maintenance and self-regulation of these systems. Thus, there is a need to integrate additional biotic and physical elements into dredge-sediment engineering to maximize the successful and beneficial use of dredge material for both large-scale marsh creation and small-scale marsh enhancement.

Because of the high cost associated with hydraulic dredging, this study was coordinated with the Louisiana Department of Natural Resources (LDNR) to provide a cost-efficient opportunity to study marsh nourishment on a landscape-scale not normally available through traditional research funding. Collaborating with LDNR engineers, researchers from the School of Plant, Environmental & Soil Sciences and the Department of Oceanography & Coastal Studies were able to conduct a large-scale, manipulative and multi-year study to assess the effects of dredge sediments on marsh recovery following a catastrophic event.

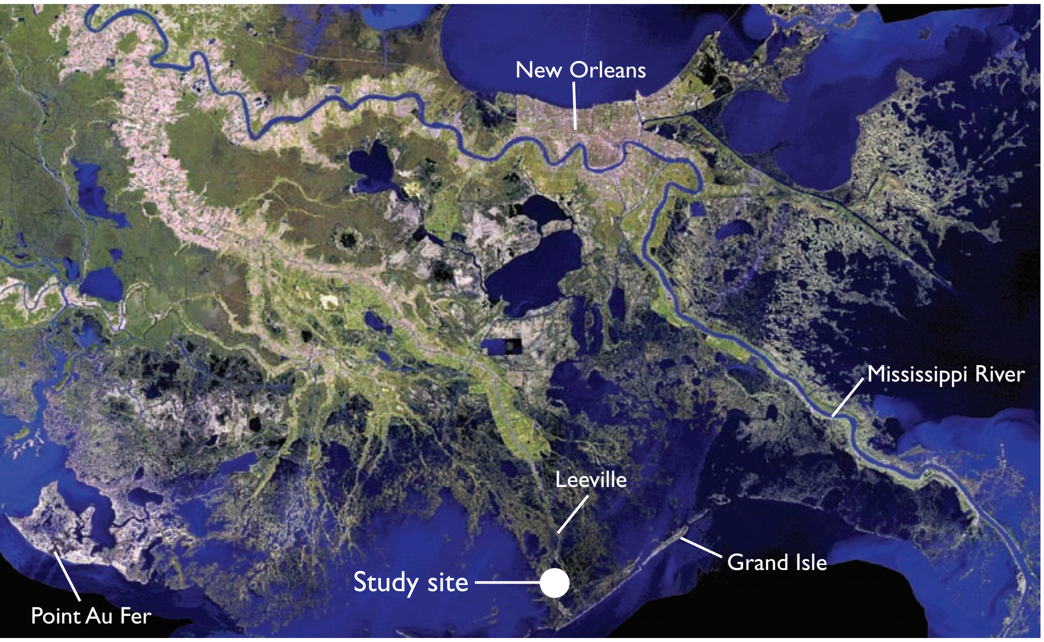
Four primary objectives of this study were to:

(1) Assess spatial changes across treatments and controls throughout the life of the study.

(2) Construct a hydrologic model to assay the distribution, frequency and duration of flooding effecting treatments and controls.

(3) Assay physico-chemical factors controlling natural vegetative recruitment and recovery.

(4) Determine the effects of artificial plantings and supplemental nutrients on vegetative recovery, recruitment, succession, and above-ground productivity.



LSU AgCenter researchers conducted a large-scale, multi-year study to assess the effects of dredge sediments on marsh recovery. Note the 40-acre study site south of Leeville. This satellite image is from 2002 and available on the U.S. Geological Survey Web site.

Michael D. Materne, Instructor, School of Plant, Environmental & Soil Sciences; Irving A Mendelssohn, Professor, and Angela Schrift, former Graduate Student, Wetland Biogeochemistry Institute and Department of Oceanography & Coastal Sciences, LSU, Baton Rouge, La.; Ashley Wilson and Sheila Rohwer, both Research Associates, School of Plant, Environmental & Soil Sciences, LSU AgCenter, Baton Rouge, La.

Figure 1. 1998 pre-dieback and pre-treatment aerial photograph showing sediment treatment, control and reference marsh sites. Both the treatment and control boundaries are overlayed for reference.

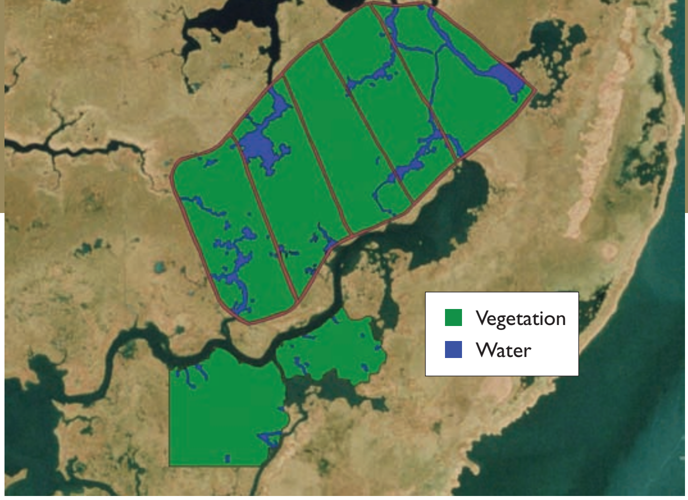


Figure 2. Same aerial photograph as shown in Figure 1 but with the habitat layers highlighted for contrast.

This study was conducted on about 40 acres of a large marsh die-back (about 110,000 acres) that occurred in Louisiana's saline marshes in 2000 and 2001. The project design consisted of constructing five 6-acre contained cells that received hydraulic sediment pumped over ambient marsh in depths varying from 5 inches to 20 inches.

The project design also included two controls, which were four-acre unconfined cells that did not receive sediment, and two healthy reference (ambient) marshes adjacent to the project site. Sediments were hydraulically dredged material from Bayou Lafourche in the form of a sediment-slurry at a ratio of about 25 percent solids to 75 percent water-by-volume. The sediments were pumped into the marsh in the fall of 2002.

Soil, Plant Measurements

Approximately 210 linear sample points were established across the sediment treatment, control and reference cells. A number of vegetative responses—such as species recruitment, density and cover—were measured in the fall of 2003, in the spring of 2004, and again in the fall of 2004. Concurrent with the vegetative recruitment measurements, several physico-chemical variables—such as reduction-oxidation potential, bulk density, organic matter, electrical conductivity, pH and soil particle distribution—were measured during each sampling period. In addition, extractable ammonium nitrogen, nitrate nitrogen, phosphorus and exchangeable calcium, magnesium, potassium, sodium, iron, manganese, copper and zinc were measured.

Within the sediment treatment, control and reference cells, we established 430 plots of six plant species treatments. Species included *Avicennia germinans* (black mangrove), *Distichlis spicata* (saltgrass), *Juncus roemerianus* (black needlerush), *Spartina alterniflora* (smooth cordgrass), *Spartina patens* (marshhay cordgrass) and unplanted. Half the vegetative plots received supplemental nutrients, and the other half received no additional nutrients. Response variables included survival, density, spread and several above-ground productivity measurements.

Spatial Change Assessment

A geographical information system (GIS) project was created by integrating a series of time-period base maps, using high resolution geo-referenced aerial photographs from which a geospatial dataset could be developed and subsequent change could be accurately measured across the life of the study. Six base maps were used to develop the geospatial indices. These included aerial photographs taken by the U.S. Geological Survey (USGS) in 1998 and 2001. The remaining four base maps were flown under contract for this study in April 2003, December 2003, December 2004, and December 2005.

We established common control polygons placed over each base map to restrict attribute delineations to a fixed constant and to provide a summary check to ensure accuracy across multiple base maps. Summary tables were indexed by attributes, and area measurements were created for each map series, compiled and used for comparison analyses.

Hydrology

An additional objective of this study was to assess the hydrologic-elevation effects on vegetative recovery resulting from sediment enhancement. To accomplish this we installed a YSI model 600LS sonde, equipped with multi-sensors and a vented level system, to record changes in both water level and salinity values. We measured water temperature, specific conductance, salinity and water levels at 30-minute intervals. The sonde logged approximately 21,000 entries continuously over a 15-month sampling period, including through both hurricanes Katrina (Aug. 29, 2005) and Rita (Sept. 24, 2005).

For quality control and quality assurance checks, a set of real-time measurements was taken at the end of each quarterly redeployment and checked against applicable standards before leaving the sonde unattended. In addition, a water sample was taken and analyzed under laboratory conditions as an additional check. Several statistical hydrograph models were constructed to assess flooding distribution, frequency, duration and depth across key elevations as well as to determine possible correlations between flooding, salinity and elevation.

Study Results: Spatial Change Assessment

Before the dieback event in 2000, we found a robust marsh with emergent vegetative cover within both the sediment treatment and control areas of the study sites. See Figures 1 and 2. Vegetation within the sediment treatment boundaries was the dominant feature with 91 percent cover followed by permanent open water at 9 percent. The control areas also contained vegetation-to-water in approximately the same proportion as that of the treatment area, with 98 percent vegetation and 2 percent water.

By November 2001 (post-dieback and pre-sediment treatment), we found extensive areas of vegetative loss. See Figure 3. Using the same boundaries and delineation methods used with the 1998 base map, we used the dark gray signature of the reduced plant stubble and exposed soils found on the 2001

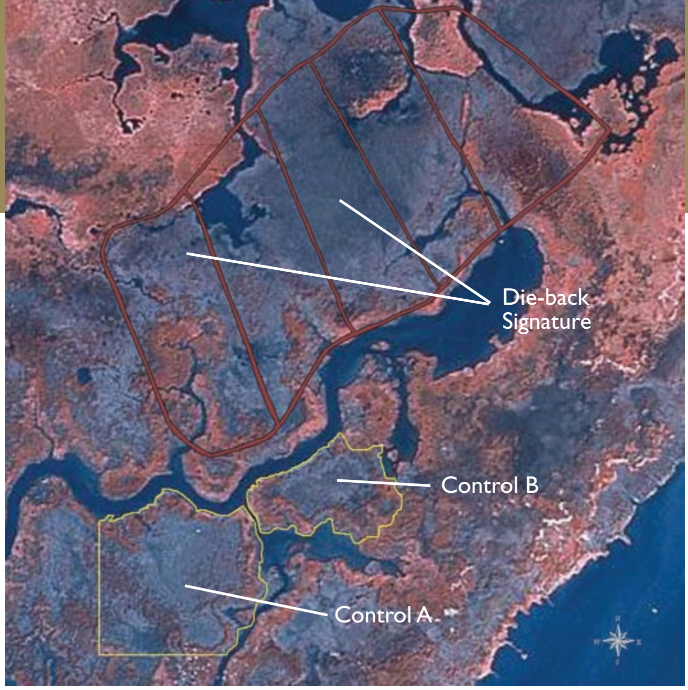


Figure 3. 2001 post-dieback and pre-treatment aerial photograph showing three habitat signatures, remaining vegetation, dieback and water.

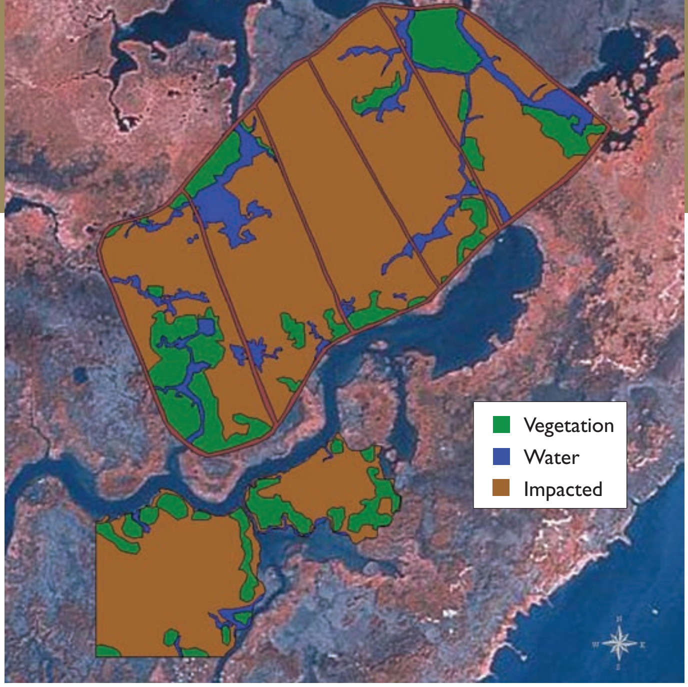


Figure 4. Same aerial photograph as shown in Figure 3 but with habitat layers highlighted for contrast.

maps to delineate habitat loss resulting from brown marsh effect within the study area. In addition to healthy emergent marsh and open water bodies, we added a third attribute to the 2001 dataset to account for impacted (dead) marsh as affected by the brown marsh events.

We found a significantly large amount of marsh loss in both the pre-sediment treatment and the control sites of the study area. Marsh loss within the study area followed the same uniform pattern seen throughout the Barataria-Terrebonne Basin. That is, the greatest mortality occurring in the marsh interior with lesser degrees of mortality along shorelines and tidal creek banks suggested a correlation with tidal flushing.

Comparing 2001, 2003

We compared habitat change from 2001 (brown marsh) to spring 2003 (four months post-sediment treatment) across three habitat variables — vegetative cover, impacted soils and permanent open water. Four months after treating the area with additional sediments, there was little statistical change across the sediment cells. By spring of 2003, there was a 10 percent reduction in vegetative cover from that found in 2001. Impacted acres remained static with less than a 1 percent increase, and open water increased nearly 18 percent.

Although there were relatively small statistical changes within test variables, there were significant physical changes in habitat distribution, particularly with vegetation and water bodies. For example, in comparing the location of healthy vegetation between 2001 and spring 2003, we noted that what remaining relatively healthy marsh can be seen in the 2001 aerials as a pinkish-red signature in Figure 3 and as the dark green overlay in Figure 4 is clustered around tidal creeks and contained in fairly discrete stands of vegetation.

In spring 2003, however, all of the larger stands have disappeared, and vegetation reappears as small, randomly distributed clumps not particularly associated with any apparent surface features such as water or pre-treatment standing crop. It would have been reasonable to assume that post-treatment vegetative recovery would have been concentrated in areas where pre-treatment vegetative communities existed. Historically, above- and below-ground standing crops have proven to be rich sources for accelerating vegetative recovery in marshes that have been heavily impacted or in newly created marsh. Figure 6 shows the scattered (green overlay) area of plant recovery four months post-sediment treatment. We observed in this study, however, a complete redistribution of plant materials with no apparent correlation to pre-treatment standing crop.

Water distribution changes paralleled that of vegetation, but the changes resulted from different mechanisms. For comparison, we delineated the location of tidal channels (red outline) on the pre-treatment 1998 imagery (Figure 5) and overlaid these channels on the post-treatment spring 2003 image (Figure 6). For contrast, we delineated and colored existing water (dark blue) and vegetation (dark green) on the 2003 image. Note that only in the immediate area, where the retention levees were intentionally breached (marked by white circles in Figure 6), was there some minimal return to the original watershed pattern. For the most part, water bodies within the treatment cells did not return to their original patterns. Rather, they re-established primarily along levee excavation lines.

Plant Cover Increases

For the purposes of this study, we defined net marsh loss as the combined losses in both emergent marsh and increases in water bodies — that is, emergent marsh that remains unvegetated (exposed soils) and an increase in water area from its original baseline value.

We found that at the end of the study period, the treatment sites had recovered to 94 percent of their pre-dieback marsh conditions with a net loss of 6 percent, while the control sites recovered to 87 percent of their pre-dieback conditions with a net loss of 13 percent.

We found no net losses within the ambient (reference) marshes that were not impacted by the 2000 dieback. Compare Figures 3 and 4 (post-dieback, pre-treatment) with Figures 7 and 8 (24 months post-treatment) for visual comparison of habitat change.

Study Results: Hydrology

To assess water and salinity effects for the study area, we constructed a number of hydrographs to determine flooding

Figure 5. This visual is the 1998 image with the pre-sediment treatment locations of tidal channels outlined in red.

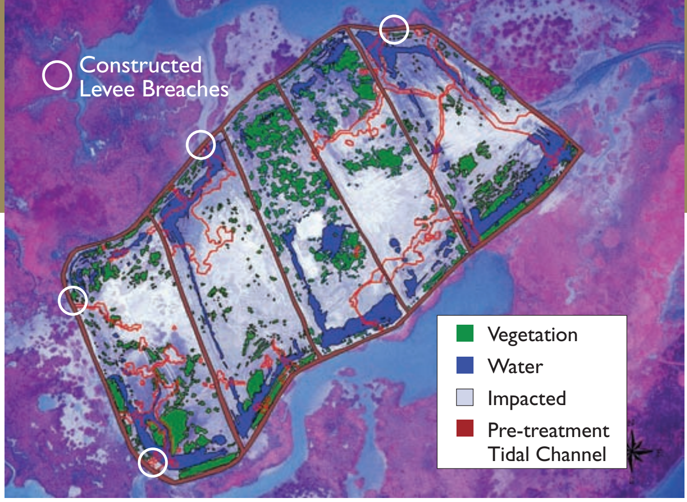


Figure 6. This is a post-sediment treatment image (spring 2003) with the 1998 channel overlay. Note that virtually all of the original site hydrology has been changed and for the most part has been replaced with isolated discrete shallow water bodies.

Research completed from this study provides a better understanding of the hydrologic-soil-plant relationships and has shown that the impacts of a large-scale, severe disturbance in a subsiding salt marsh can be minimized through the addition of sediment slurries.

frequency, distribution, duration and depth across selected elevations, as well as to determine possible correlations between salinity, flooding and rainfall. Over the 15-month study period, we found tidal cycling to follow a diurnal (one high and one low tide per 24.8 hours, or one lunar day) cycle, modified by overriding weather effects such as rainfall and storm events. In addition, we found the study sites to be a strong saline marsh (average salinity 21 parts per thousand) and water levels fluctuating between minus 6.9 inches below and 19.8 inches above ambient marsh. The average water level for the 15-month period was minus 0.13 inches, or just slightly below the ambient marsh surface.

In addition, we found both water level and salinity varied seasonally with the highest water levels during the summer months and highest salinity levels during the fall months. We also found that there was no correlation between tide fluctuation and salinity but a moderately strong negative relationship between rainfall and salinity.

Percent Time Flooding (Duration)

We defined flooding duration as the cumulative amount of time (expressed as percent of total) that standing water remained at or above a specific elevation. Because each recorded occurrence is equivalent to a 30-minute duration, the cumulative sum of each occurrence at or above a specific elevation would equal the total time (or percent) that the marsh was flooded.

At ambient marsh (zero elevation), we found that there were almost equal periods of surface flooding (49 percent) and drying (51 percent). This nearly one-to-one ratio of wetting and drying is optimal for plant growth by providing a balanced oxidation-to-flooding regime, critical to intertidal plant species such as *Spartina alterniflora*.

Within the control site elevations, the ratio of flooding (88 percent) to drying (12 percent) was disproportionately skewed toward wet soils. Under these flooding conditions, there is a high probability of significantly reduced soils, resulting in lower plant survival and reduced plant productivity. Plant survival within the control cells, across all species and nutrient levels, was zero. When we compared the presence or absence of vegetation along a continuous elevational profile within control site A, we found that the treatment sites would not support vegetation when the marsh surface had eroded to greater than 1 inch below the ambient marsh elevation.

Physico-chemical, Plant Response

One of the primary factors influencing plant distribution and function in Louisiana intertidal saline marshes is elevation. In low intertidal marshes, soils are generally characterized as reduced, and *Spartina alterniflora* is the dominant plant species in part because of its superior oxygen transport mechanisms and high sulfide tolerance. As waterlogging (reduction) stress decreases with increased elevation, competitive interactions cause the replacement of *S. alterniflora* with other species.

Within the lower sediment elevation treatments (5 inches to 7 inches above ambient marsh), there was rapid *S. alterniflora* recruitment with densities similar to that found in the healthy reference marsh sites. With increased elevation (8 inches to 10 inches), we found reduced *S. alterniflora* recruitment, but a significant increase in species richness. Likewise, within the higher elevational treatments (11 inches to 14 inches), there was minimal *S. alterniflora* recruitment, and the greatest increase of species richness compared to the other treatment cells, controls or the reference sites.

At elevations greater than 18 inches above ambient marsh, however, there was little to no vegetative recruitment of any species, suggesting an upper threshold of hydrologic-soil-plant interaction. Within the control cells, recruitment and species diversity was marginal in areas that received no supplemental sediment. In the absence of vegetative cover, significant portions of the control cells collapsed and reverted to open water during the course of the study.

Frequency and duration of flooding and reduction-oxidation (redox) potential have been found to correlate with elevation in tidal salt marshes. Similarly, within the study area we found redox potential and elevation to be highly related, and we identified an inverse relationship between percent time flooded and elevation at our study site. The markedly reduced redox potentials seen in the control cells can be attributed to their low elevation and increased flooding frequency and duration.

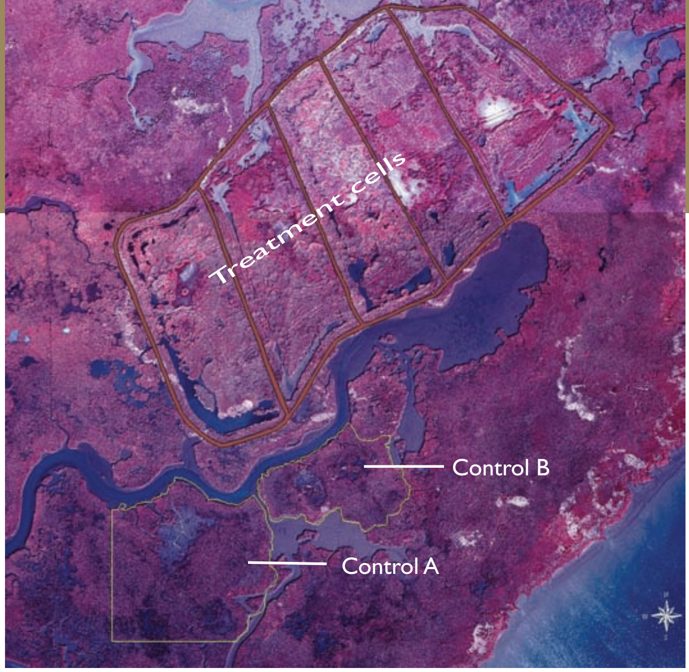


Figure 7. This visual is from the fall of 2004 – 24 months post-sediment treatment. It shows both the sediment treatment and the control sites with the control boundary overlay, but without the habitat attribute layer.

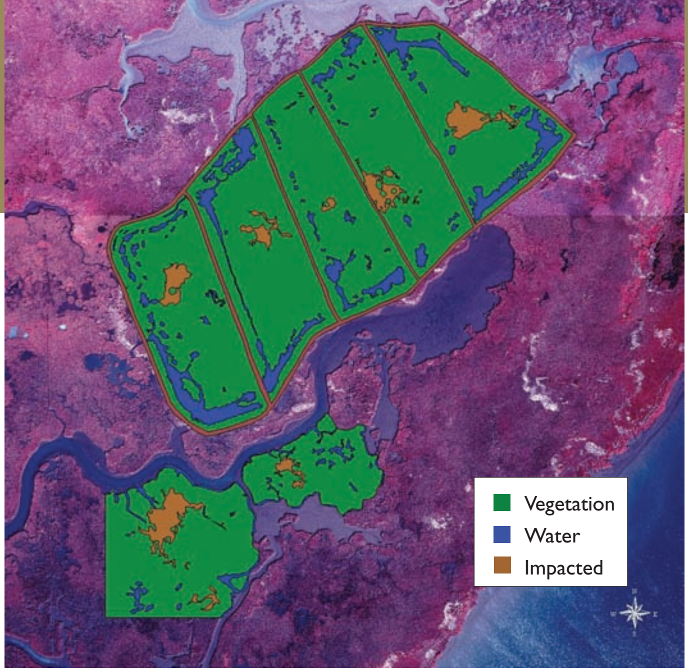


Figure 8. This is the same area, as at left, for both the treatment and control sites but with the habitat attribute layers highlighted for comparison.

Flooding duration within the control cells was 88 percent compared to 49 percent within the reference marsh. When soils are flooded, oxygen depletion is rapid because of its slow rate of diffusion and consumption by facultative and anaerobic microorganisms during respiration.

Sediment Decreases Sulfide

These microorganisms use oxygen as a terminal electron acceptor converting oxidized compounds into their reduced states, potentially forming toxins, such as hydrogen sulfide. High sulfide levels have been found to decrease productivity and are, therefore, detrimental to the plant growth. We found soil sulfide concentrations to sharply decrease with the addition of sediment, and treatment cells receiving sediments were found to have no measurable concentrations of interstitial sulfide.

In contrast, we found high sulfide concentrations and low root oxygen concentrations in the control cells that would have inhibited nitrogen uptake and contributed to high average ammonium nitrogen concentrations, thus causing a reduction in plant growth.

In addition, the concentration of salts such as magnesium, calcium, sodium and potassium throughout our study area was within normal ranges and in many instances not significantly different among or between treatment levels and marsh types. These results imply that salt concentrations were not a factor limiting plant colonization at any of the sediment elevations within the study site.

High bulk density (a measure of mineral content) has been shown to increase plant recovery and productivity. Mineral matter can improve marsh vigor by increasing nutrient availability and by decreasing toxicity via providing metals (iron and manganese) that precipitate with sulfide.

Bulk density was significantly higher in sediment-subsidized areas, and specific treatment levels had marked increases of iron, copper, manganese, zinc, calcium and phosphorus compared to reference marshes. Plant survival across all treatments ranged from excellent to extremely poor within the treatment and control cells. There were no surviving plants at the control sites, indicating that sediment addition was the critical factor in species survival.

When assessing nutrients and elevation as main treatment effects, we found no significant difference across any plant species treatments. For example, survival within the fertilized plantings averaged 72.7 percent compared to 71.6 percent in the unfertilized plantings.

Elevation Affects Species

When we combined elevation and species as treatments, we found that species segregated along elevation. For example, *S. alterniflora*, which is typically an intertidal species, performed better at lower elevations than at higher elevations while *D. spicata*, which prefers a less saturated soil, increased with increases in elevation. *Avicennia germinans* was the only species that performed equally well across all elevations. The control sites, which were considerably lower (about minus 6 inches below ambient marsh) had total mortality across all plants species treatment. It should be noted that *S. alterniflora* (the pre die-back dominant species) reached vegetative equivalency to that of normal marsh in less than two complete growing seasons across all treated cells, with the exception of the untreated control cells.

Wetland loss is indeed acute in Louisiana. The effects of increasing demands on petroleum exploration, global climate changes, worldwide rise in sea levels and human pressures for coastal development will remain critical issues well into the future. Research completed from this study provides a better understanding of the hydrologic-soil-plant relationships and has shown that the impacts of a large-scale, severe disturbance in a subsiding salt marsh can be minimized through the addition of sediment slurries.

When combined with other coastal restoration research, the information from this study will provide coastal wetland project planners, designers and builders additional management strategies, which will better incorporate vegetative diversity and productivity into beneficial-use sediment engineering. ■

LSU AgCenter fisheries agent David Bourgeois identified seashells for Dexter Parent of Ascension Parish on the beach at Rockefeller Refuge in Cameron Parish.

Coastal Roots

Students learn science, help protect Louisiana from sea surge

Some of the plants that helped buffer the southeastern Louisiana coast during hurricanes Katrina and Rita in 2005 were planted by youth groups participating in the LSU Coastal Roots program.

"We started growing wetland plants from seeds in the schools to help some of the coastal erosion in this area," said David Bourgeois, an LSU AgCenter and Sea Grant agent who helped start Coastal Roots in 1998 in Lafourche Parish.

The other two principal players in the program since its beginning are Ed Bush, horticulture professor, and Pam Blanchard, formerly Sea Grant educational coordinator and now professor with the LSU College of Education.

Together they developed an educational program as a way to bring awareness of Louisiana's vanishing coast to schools. Aimed at elementary and secondary school students, the program helps young people learn to grow coastal plants and then place them in the wetlands to help prevent erosion. The program provides wetland plant and habitat educational materials to teachers and students. The lessons are designed to not only teach about wetland plants but also the biology behind how wetland plants grow. Lesson topics include plant identification, wetland habitats, photosynthesis, composting, pollination, genetics, wetland soils and global warming.

"When the program first started, we solicited schools to participate," Bourgeois said. "Now the teachers come to us. They have to seek their own funding, but they want to do this."

Currently, 17 schools in nine parishes participate in Coastal Roots. The schools establish plant nurseries. They grow seedlings of native plants and then transplant the plants in coastal restoration projects.

From 2001 to 2006, about 1,640 students (grades 4-12) in 21 schools were directly involved in learning and doing something about coastal restoration, Blanchard said. Other numbers include 12,467 plants of nine plant species transplanted and 29 acres of habitat replanted.

Photos by Bruce Schultz

Bourgeois explains the importance of shoreline vegetation to Hannah Fontenot of Evangeline Parish, Will Fox of Ascension Parish and Matthew Gauthier of Vermilion Parish.

Blanchard said the plantings helped stabilize levees and shorelines, reforest coastal habitats and create a Louisiana black bear corridor. The plantings have occurred at conservation areas, state and city parks, shorelines, nature preserves and hurricane protection levees.

The parishes involved in the program include Assumption, East Baton Rouge, East Feliciana, Jefferson, Lafayette, Lafourche, St. Charles, St. James, Terrebonne, Vermilion and West Baton Rouge.

"This is more than growing plants and then going on a field trip to plant them," Bourgeois said. "The students learn scientific principles and about the environment."

Most of the plants, Bourgeois said, serve to trap sediment on shorelines or levees. Plants at the water's edge establish roots to help hold the soil while other plants farther from the water provide a buffer zone against losing soil to the effects of storm surge.

"These students know what they're doing is helping save Louisiana's coast," Bourgeois said.

Students grow and plant wax myrtle and cypress trees and black mangrove to help restore the wetlands to what experts believe was their original state. Wax myrtle has deep roots, provides seeds for birds, grows quickly and reproduces easily. It also provides habitat and food for migrating birds. Because wax myrtle can tolerate some salt, it is planted in brackish waters. Cypress is planted on higher ground.

Black mangrove is also salt-tolerant and suited for areas near the coast. Students plant the seeds from black mangrove in the winter and grow them in containers. Restoration plants established by students in the spring of 2004 were about a foot tall when hurricane Katrina hit Louisiana's coast, Bourgeois said. Although there was some minor damage to the plants, most survived and are providing additional shoreline protection as mature plants.

"Because those plants stayed there and held the soil, we know the program is doing some good," said Bourgeois.

■ **Rick Bogren and Linda Foster Benedict**

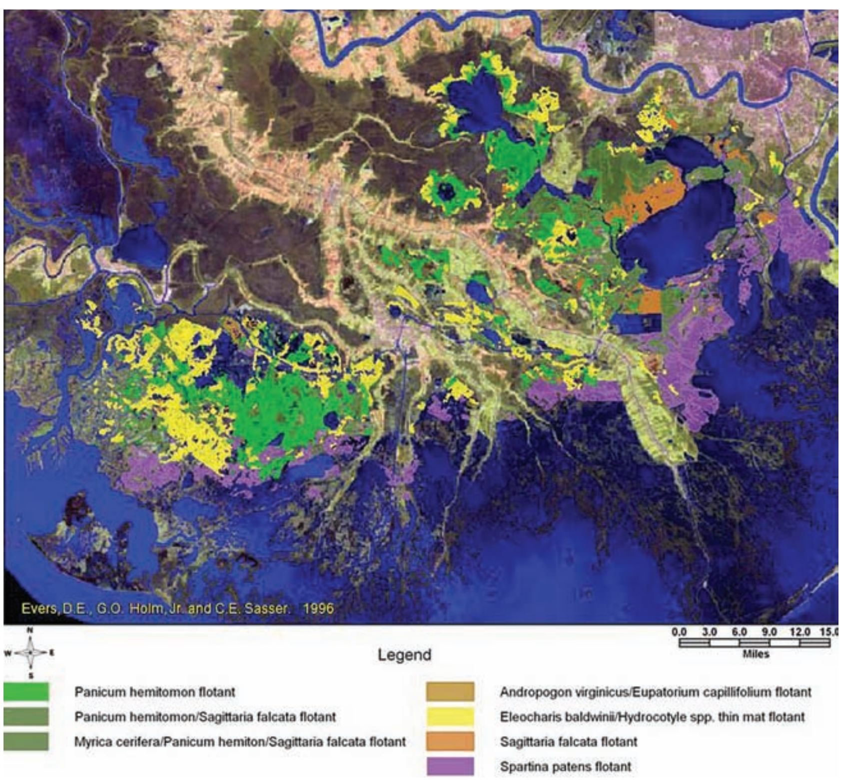
Restoring Freshwater FLOATING Marsh *in Coastal Louisiana*

Charles E. Sasser, Michael D. Materne, Jenneke M. Visser, Guerry O. Holm and Elaine Evers

Coastal wetland loss has been widespread in Louisiana over the past half century and is related to a variety of causes. These include hydrologic changes from increased flooding duration and frequency, saltwater intrusion, plant-eating animals – particularly nutria – and water quality.

Louisiana coastal wetlands include large areas of salt marsh nearest the Gulf of Mexico shoreline with decreasing salt water influence in the brackish, intermediate and freshwater marshes farther inland from the coast. In the freshwater areas of the coast, major losses have occurred in the floating marshes that have historically covered extensive areas, particularly in the Mississippi River Deltaic Plain (MRDP) region, and continue to form a significant portion of the Louisiana coastal marshes. Landscape data from 1990 in the Barataria and Terrebonne basins of the MRDP indicate that buoyant marshes covered about 70 percent of the freshwater and low salinity marsh zones, an area of more than 350,000 acres.

Figure 1. A map of the flotant in the Barataria and Terrebonne basins, 1996.



The classic example of floating marsh (flotant) in Louisiana is a marsh dominated by maidencane. It has a 1- to 2-foot thick, buoyant, organic mat of densely intertwined roots and rhizomes in a mostly organic matrix that floats continuously, rising and falling with water level changes. This ability to float vertically as water level increases effectively neutralizes flooding as a stress, while providing a continuously wet environment for vegetation growth.

Through the middle of the last century, thick-mat flotant marsh was expansive and nearly unbroken covering a large part of the freshwater regions of the coast. Since then, however, the maidencane floating marsh has changed in many areas to open water or a low productivity, highly disturbed form of floating marsh called the thin-mat flotant, dominated by spikerush. In contrast to the highly productive maidencane marsh, spikerush marshes grow on thin (less than 10 inches) floating mats, which are relatively fragile. In most cases, the thin-mat flotant marshes will not support the weight of a person. By contrast, a healthy thick-mat flotant is easily strong enough to support the weight of large animals.

Maidencane Decreases

Both the thick-mat maidencane and thin-mat spikerush marshes are supported by highly organic substrates with very low mineral densities and high organic matter content. Aboveground vegetation productivity is considerably higher in the maidencane marsh compared to the spikerush marsh. Between 1968 and 1992, maidencane-dominated marshes in the Barataria and Terrebonne basins decreased from 67 percent to 19 percent of the fresh and low-salinity marshes. At the same time, spikerush marshes increased from 3 percent in 1968 to 53 percent in 1992. The vegetation habitat map (Figure 1) illustrates the widespread distribution of the thin-mat floating marsh in the MRDP.

We are increasingly optimistic that restoration of deteriorated freshwater floating marshes is possible by initiating new growth in shallow, open water areas and improved biomass production and soil stabilization in the remnant thin-mat marshes. Floating marshes appear to be unique in their origin, the way they function and their responses to changing environmental conditions. For successful coastal restoration, the implications of these unique characteristics must be considered in the design of restoration projects.

Charles Sasser, Professor, School of the Coast & Environment and School of Plant, Environmental & Soil Sciences; Michael D. Materne, Instructor, School of Plant, Environmental & Soil Sciences, LSU AgCenter, Baton Rouge, La.; Jenneke M. Visser, Associate Professor, Guerry O. Holm, Postdoctoral Researcher, and Elaine Evers, Research Associate, School of the Coast & Environment, LSU, Baton Rouge, La.

Figure 2. The below-ground material of maidencane forms an extensive root and rhizome distribution that creates a fibrous and buoyant organic root mat.

Photo by Jenneke M. Visser

It is important to recognize the plant-substrate unit on which plants grow as the foundation of a floating marsh. Because the floating substrate is formed by the plants that grow in it, it is not a separate unit as, for example, soil in an agricultural field. In the Louisiana coastal ecosystem, the native freshwater plant, maidencane, plays a key role in the formation and maintenance of coastal freshwater peat soil mats and is the primary plant species used in restoration efforts. The below-ground material of maidencane forms an extensive root and rhizome distribution that creates a fibrous and buoyant organic root mat (Figure 2). This extensive network of fibrous roots and rhizomes is crucial for building the floating marsh mats characteristic of most of our highly organic freshwater marshes. Other marsh plants that commonly occur in this highly buoyant floating mat do not on their own produce the extensive below-ground material necessary for thick-mat development.

Two Enhancement Projects

The Coastal Wetlands Planning, Protection and Restoration Act of 1990 provides federal funds for planning and implementing projects that create, protect, restore and enhance coastal wetlands of the United States, including Louisiana. Two demonstration projects were designed and implemented under this act to develop methods for restoration of degraded freshwater floating marsh.

The first project demonstrated the enhancement and recovery of the remnant thin-mat floating marsh in deteriorated freshwater marshes by transplanting maidencane and protecting from nutria grazing. After four growing seasons, maidencane coverage from transplants into the thin-mat marsh protected from nutria expanded from an initial 4 percent at planting to greater than 80 percent after four years. The maidencane plantings doubled the biomass above- and below-ground, relative to controls, and improved soil strength, which is an indicator of marsh health. The overall conclusion from the project is that thin-mat floating marsh can be enhanced and restored by transplanting maidencane into the mat and protecting from nutria grazing (Figure 3).

The second floating marsh restoration demonstration project is under way at the LSU AgCenter and is aimed at restoring open water areas within degraded freshwater floating marsh. Implementation of this project began in 2004 and consists of two phases. The first phase is the development of artificial floating marsh systems. This part of the project included the development of a floating system that provides the structure to keep the substrate in place and adequate buoyancy for maidencane plants to become established and grow a self-sustaining mat. Thus, structures using a variety of materials were evaluated during testing in ponds at the LSU AgCenter's Aquaculture Research Station in Baton Rouge (Figure 4). At the same time researchers at the University of New Orleans are assisting through a subcontract provided by the LSU AgCenter to look at the plant response to nutrients, flooding and substrate in order to develop methods to maximize the establishment and growth of maidencane in the floating structures.

Over the first 18 months of the project, 27 designs were constructed and tested in research ponds at the Aquaculture Station. The designs used various structural materials – pine and cedar wood, bamboo, PVC, Styrofoam – or combinations of these materials. Mat materials tested included burlap, jute netting, coconut, straw-coconut, birch and hydroponic growth

Figure 3. Maidencane growth within exclosures at the Terrebonne Basin thin-mat floating marsh restoration demonstration project field site.

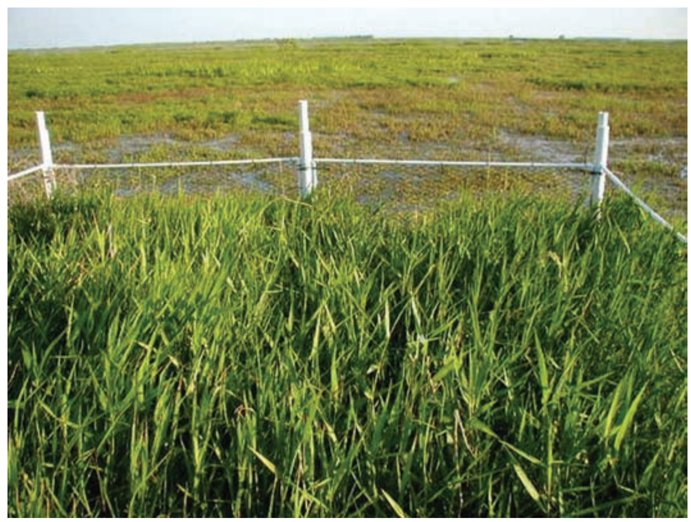


Photo by Charles E. Sasser

Figure 4. Testing of artificial floating marsh system designs on Aug. 22, 2005, at the LSU AgCenter Aquaculture Research Station in Baton Rouge.

Photo by Jenneke M. Visser

on a poultry wire base. Substrate material used included hardwood mulch, peat and a peat-bagasse mixture. Plants were established from maidencane harvested from Louisiana donor marshes and grown in LSU AgCenter greenhouses at Baton Rouge. Experiments included testing whole plants, rhizomes, stem material and plant pieces as a starter material to determine the types of plant material most suitable for plant establishment**.**

Efforts are under way to develop a more cost-effective method of reintroducing maidencane into degraded marsh areas.

Field Testing Designs

The second phase of the project is field testing the best designs in a natural marsh setting. Two successful designs based on findings related to structural integrity, buoyancy and growth response from the research pond investigations were brought forward for field deployment at the Mandalay National Wildlife Refuge in Terrebonne Parish. The refuge is located within a wetland area that once supported a large expanse of thick-mat floating maidencane marsh that has now degraded to open water and remnant freshwater marsh. The two successful designs were a 4-foot by 10-foot terrace design using capped PVC pipe for buoyancy and a 4-foot by 4-foot bamboo square design using bamboo material for buoyancy – both with wire containment baskets for plant material. Two hundred terrace structures and 100 bamboo square structures were deployed at Mandalay Refuge in the spring of 2006 using either maidencane whole plants in peat pots or stem material as the plant material source (Figure 5). Because nutria grazing in the open marsh system is a major problem, most structures were fenced.

After a full growing season in the field, all of the structures at the Mandalay Refuge have remained intact, with no loss of structural integrity. Fortunately, the 2006 hurricane season was mild, with no tropical storms or hurricanes causing problems to the project area or the Louisiana coast. The vegetation planted in the structures has performed well, with all maidencane treatments having average cover values exceeding 60 percent. Total cover of all emergent plants averaged 90 percent across all treatments. Maidencane was dominant (Figures 6 and 7).

Establishment with potted plants resulted in more rapid cover increases than establishment from stems. By the end of

Figure 5. Deployment of vegetated artificial floating marsh system structures at the Mandalay marsh site in April 2006.

Photo by Daniel Sasser

Figures 6 and 7. Condition of vegetation in artificial floating marsh system at the Mandalay marsh sites on June 1, 2006 (left) and Sept. 11, 2006 (right). In the June photo the structures are plainly visible. By September, however, the robust growth of maidencane hides the structures.

Photo by Brian Milan

Photo by Jenneke M. Visser

the first growing season, however, differences in cover between establishment techniques were small, especially in the sites planted first.

The below-ground growth of roots and rhizomes was equally impressive (Figure 8). Maidencane rhizomes started spreading outside of the structures as the growing season progressed. The expectation is that this lateral spread will continue and eventually join the floating maidencane islands into a continuous marsh, achieving the desired restoration goal. In addition to the lateral spread of maidencane, other species including water hyacinth and frogbit rafted against the structures, providing some additional opportunity for marsh formation.

Preliminary Findings

Our preliminary findings after the first year of deployment are that the floating island structure designs using PVC and bamboo materials for buoyancy were successful. All structures remained buoyant and structurally intact in the first growing season. Coconut, birch, coconut-straw mats and chicken-wire baskets were successfully used to establish maidencane plant material. Maidencane cover increased whether established from marsh plugs, whole plants (rhizome and stem material), below-ground material, stems or peat pots.

Based on the preliminary results of these demonstration projects and previous research, restoration and enhancement of much of Louisiana's coastal freshwater marshes appear to be possible by controlling nutria grazing and transplanting exceptionally productive mat-forming plant species such as maidencane directly into the degraded areas. This includes both transplanting directly into existing remnant thin-mat flotant marshes, as well as growing back marsh using maidencane-planted artificial floating islands in adjacent shallow open water areas where conditions are favorable.

Currently at the LSU AgCenter, pilot-scale efforts are under way to develop a more cost-effective method of reintroducing maidencane into degraded marsh areas. Because maidencane is not a prolific producer of seeds, the reintroduction of this desirable species on remnant marsh mats in degraded areas by aerial distribution of seeds is not possible at this time. Preliminary work at the LSU AgCenter to aerially distribute plant material from small root and stem pieces, however, may provide a valuable option for helping restore coastal floating marshes. ■

Figure 8. Measurement of root mat depth at the Mandalay marsh field site, October 2006.

Photo by Charles E. Sasser

BREEDING Native Coastal Plants for Use in Coastal Wetland Reclamation and Preservation

Stephen A. Harrison, Niranjan Baisakh, Michael D. Materne, Carrie Knott, Prasanta K. Subudhi and Herry S. Utomo

The application of proven plant breeding methods to enhance the usefulness of native plants for coastal reclamation has tremendous potential. The LSU AgCenter has put together a multi-disciplinary team of plant breeders, geneticists and ecologists to determine the potential of native coastal plants for reclamation activities. Each plant species has distinctive characteristics for adaptation and survival in coastal environments, but most also have traits that limit their widespread use in conservation and preservation activities. The first step is to determine genetic variability and identify traits within each of the candidate species that might be enhanced. Proven plant breeding and genetic methods are applied to overcome such limitations as poor seed set, reduced vigor, slow growth or lack of salt tolerance.

The LSU AgCenter Coastal Plant Program, in cooperation with the Natural Resources Conservation Service, has jointly released several varieties for vegetative and wildlife restoration of barrier islands, saline and brackish marshes. These varieties are widely used for contract restoration by government and private agencies and are the basis of a developing Louisiana wetlands nursery industry. Variety and population development activities are well under way for smooth cordgrass, sea oats and bulwhip. Genetic improvement activities have been expanded to include additional species important to Louisiana's coastal environments, and a full-time plant breeder was hired in April 2007 to direct variety development activities for coastal plants.

Developing Spartina Varieties

Smooth cordgrass (*Spartina alterniflora*) has received the most research attention because it is the predominant marsh grass and tolerates a wide range of salinity from slightly brackish to seawater. A single plant grows to a clump of several feet in diameter during a summer, and it thrives in coastal marshes and intertidal regions along the Gulf Coast. The dense canopy of smooth cordgrass provides a significant buffer against wave energy. It controls erosion, traps suspended sediments and produces significant amounts of organic matter. It grows parallel to the shore in water up to 18 inches deep and in clumps on mud flats.

Photo by Prasanta K. Subudhi

Smooth cordgrass tolerates a wide range of salinity from slightly brackish to seawater.

The majority of restoration contracts specify that the variety Vermilion should be used since it is the only released variety along the Gulf Coast. The widespread use of Vermilion is a cause for concern because of genetic vulnerability. Restored areas planted exclusively to Vermilion lack the ability to buffer against changes in the environment or insect and disease pests. Vermilion is not a particularly good seed producer and, therefore, does not lend itself to large-scale seed harvest and planting.

An initial collection of seed was harvested from 126 sites across the Gulf Coast. These were planted at several locations in south Louisiana and evaluated for vegetative vigor, spread, pest resistance, adaptation and seed production. They were evaluated over a number of years and locations. Thirteen of these have been chosen as candidates for release as vegetative varieties. These selections have excellent vegetative growth and are good seed producers. They are diverse in geographic origin and have been shown to be genetically diverse using molecular marker technology. The release of new smooth cordgrass varieties is significant because it gives restoration practitioners the ability to plant diverse populations that are proven performers. An excellent strategy for utilization of these lines will be to transplant them in clusters dispersed throughout large open mudflats. The clusters should cross-pollinate, produce lots of seed, and reseed the open areas with a superior and diverse population within a short time.

The superior smooth cordgrass lines can be planted in a randomized manner within flooded rice fields for seed production, which may spawn a seed-based restoration industry. The resulting seed

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harvested from these ponds can be flown across large areas of the marsh to produce a genetically diverse population of vigorously growing plants. Seed production ponds can be re-established from foundation plants of these elite lines in a prescribed manner to ensure quality and purity.

Other Coastal Plant Species

California bulwhip (*Schoenoplectus californicus*), also known as California bulrush, tolerates deeper flooding than most species used in coastal restoration projects. It has an extensive network of rhizomes and forms dense colonies. It traps sediment effectively, reduces wave energy and provides better conditions for the establishment of other vegetation along the shoreline. The potential for use of California bulrush is limited by its low salt tolerance. California bulrush with greater salt tolerance would have an expanded range and will be useful in brackish wetland preservation and restoration efforts.

California bulwhip, also known as California bulrush, tolerates deeper flooding than most species used in coastal restoration projects.

Preliminary greenhouse research identified eight native bulwhip lines with improved salt tolerance, which will be used to initiate a genetic improvement program to develop even more tolerant lines. Twenty genotypes of California bulrush are being evaluated in coastal environments for salt tolerance and vegetative vigor. These include nine elite lines in freshwater from a previous trial, eight lines selected as salt-tolerant under greenhouse conditions, one line selected as an intermediate, one line selected as a poor performer and the variety Restorer.

An additional 756 regenerated plants of California bulrush derived from cells selected for improved salt-tolerant levels were grown under flooded conditions and continuously exposed to salt concentrations of zero, 6, 12 and 18 parts per thousand for nine months. Lines selected for salt tolerance in the greenhouse will be advanced to marsh site testing. Selected lines will be increased for further field testing. Superior lines for vegetative growth and salt tolerance will be released as varieties for use in coastal wetland restoration activities and will form the foundation of a breeding and genetic improvement program.

Sea oats (*Uniola paniculata*) are dune-loving plants with extensive root systems that trap sand and stabilize sand dunes. Sea oats prefer a high dune environment, and most East Coast lines are not well-adapted to the low profile sand dunes characteristic of the Louisiana coast. Production of sea oats plants in large numbers is a challenge for coastal restoration managers because of poor seed set, poor germination and seed dormancy. Sea oats are commonly propagated in nurseries from field-collected seeds, but limited seed production by the native populations is a barrier to the success along the Louisiana coast. Seed production in the Louisiana populations of sea oats is extremely low compared to the population along the southeastern United States. Many of the sand dunes along the Louisiana coast have been lost to tropical storms, and few native Louisiana sea oats populations are left. The possibility of collecting enough seeds is low because of the disappearance of natural stands.

A large collection of sea oats germplasm, representing eight southeastern Atlantic and Gulf coast states (Virginia, North Carolina, South Carolina, Florida, Alabama, Mississippi, Louisiana and Texas), was characterized at the molecular level. There was significant genetic variation in lines among states, among lines within states and among individual plants. The relationship between genetic diversity and geographic source of sea oats populations of the United States as revealed through this study will be helpful for the resource managers and commercial nurseries in selecting, moving and mixing suitable plant materials for restoration of new areas without compromising the adaptation and genetic diversity.

Photos by Prasanta K. Subudhi

Sea oats prefer a high dune environment, and most East Coast lines are not well-adapted to the low profile sand dunes characteristic of the Louisiana coast.

Replicated field trials at Holly Beach and Biloxi, Miss., before the 2005 hurricanes showed that Florida and Louisiana lines performed relatively well in Louisiana. Elite materials were harvested from each site and are under increase for additional trials. Superior lines will serve as the foundation of a genetic improvement program aimed at developing populations and varieties with superior tolerance of the dune environment in Louisiana, greater seed production, increased genetic diversity and strong vegetative growth. Varieties developed by this effort should be better adapted to Louisiana and will be useful in restoring and preserving barrier islands.

A number of other species are under preliminary investigation, including black mangrove and bitter panicum. Elite lines will be used to form the foundation of continued genetic improvement activities.

Plants provide a self-sustaining, environmentally sound and aesthetically pleasing approach to controlling coastal erosion that can persist indefinitely. Commercial enterprises to supply marsh plant material will expand as coastal reclamation activities increase over the next decade. The coastal plants project will play an important role in developing genetically superior varieties and improved technology to protect our valuable coastal ecosystem. ■

SEA OATS Micropropagation aids in coastal restoration

Prasanta K. Subudhi, Niranjan Baisakh, Diptimayee Sahoo, Stephen A. Harrison, Michael D. Materne and Herry S. Utomo

Sea oats is a valuable plant species for coastal restoration. Large numbers of sea oat plants are needed to stabilize dunes as a part of the ongoing effort to save our wetlands and coastal ecosystems. Development of micropropagation techniques by LSU AgCenter researchers will add a new dimension to the coastal restoration effort and help ensure a steady supply of sea oat plants throughout the year.

Sea oats (*Uniola paniculata*) is a native dune plant commonly pictured on tourism pamphlets for beach resorts. This grass species is frequently used for dune restoration and vegetative stabilization projects throughout its native range in the United States. It is a semitropical, perennial grass noted for excellent sand-holding ability and tolerance to drought, inundation by sea water, salt spray, strong winds and tropical storms.

Sea oats has a deep, fibrous root system that allows it to thrive in sandy environments with minimal nutrition and high sand temperature. It traps sands and builds dunes that provide protection to coastal ecosystems. The frequency of damaging tropical storms has increased in recent years, and sea oats plants help restore damaged coastal areas. LSU AgCenter researchers have developed sea oats lines for use in restoration activities and have developed a means to mass-propagate these elite lines.

Louisiana beaches and dunes are characterized by low elevation and frequent over-washing and erosion. Although this environment is quite different from the typical high dunes where sea oats plants dominate, there are sea oats lines that grow on the Louisiana coast. A primary barrier to large-scale use of sea oats for coastal reclamation in Louisiana is the limited seed production of adapted types and native populations. In comparison to other states in the southeastern region of the United States, seed set in sea oats populations of Louisiana is very low and, consequently, most of the existing natural stands of sea oats on barrier islands have been lost over time. Thus, the development of micropropagation technology is essential for large-scale use of sea oats for coastal restoration.

Planting seeds is the major method of propagation in most plants. Because seeds are the result of sexual reproduction and recombination of genes, plants resulting from seeds may differ from their parents in many attributes. Plants that are asexually propagated from vegetative plant parts such as roots, stems and leaves are usually identical to their parent since sexual recombination does not occur.

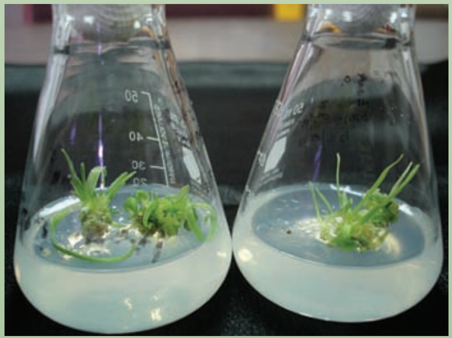
Micropropagation is an asexual propagation method in which tissue culture techniques (growing plants in test tubes) are applied in an aseptic (away from disease-producing microorganisms) environment to generate many identical plantlets. For those plant species that do not produce seeds or do not regenerate plants from vegetative tissues easily, micropropagation is a suitable alternative. It also has been an effective means of generating virus- and disease-free plants in large numbers (sugarcane, for example) and for the development of novel plants through genetic modification.

Micropropagation is a process of generating many plantlets from a small amount of plant tissue in a controlled laboratory environment. The process involves a multi-step procedure starting with selection and excision of plant parts (explants) followed by sterilization and growing in appropriate media containing all necessary nutrients for plant growth. Media composition is manipulated with different doses of growth hormones for shoot proliferation or rooting. Since microbial contamination is a major problem in tissue culture procedures, utmost care is taken to work in an absolutely contaminant-free environment.

LSU AgCenter research on tissue culture response of different sea oats lines is ongoing. We estimate that from a single explant, 100-200 plants can be generated within five to six months. Because there is concern about variation during tissue culture process, we are determining the genetic variation among these tissue culture-propagated plants using DNA fingerprinting.

We are concurrently trying to establish a protocol to generate multiple shoots, using mature plants as a source. This would allow production of large numbers of plants identical to an elite sea oats plant maintained in a nursery bed. Although we have identified a few candidate recipes for a protocol, research is still under way to identify the best concentration and combination of hormones to induce shoot proliferation in the least amount of time. Once the multiple shoots are generated, shoots can then be split and multiplied further to generate more seedlings. ■

Photo by Prasanta K. Subudhi



Micropropagation is a process of generating many plantlets from a small amount of plant tissue in a controlled laboratory environment.

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Plant Genetic Diversity
Essential for a Dynamic Louisiana Coast

Prasanta K. Subudhi, Niranjan Baisakh, Stephen A. Harrison, Michael D. Materne and Herry S. Utomo

The development of native plant materials with greater usefulness and enhanced performance in coastal wetland environments is of crucial importance to Louisiana's efforts to arrest coastal erosion and wetlands habitat loss. The key to enhanced productivity and longevity of Louisiana's coastal marshes lies in planting quality plant materials with adequate genetic diversity.

Genetic diversity indicates the presence of a variety of plant species in a particular ecosystem. Genetic diversity also involves intraspecific diversity – that is, genetic differences among the individuals of a particular species or variation at the level of individual genes. For a particular plant species, it is important to know whether individual plants are genetically similar or diverse within a population and across locations. Differences in certain traits can be indicators of genetic diversity, but the ultimate control of such heritable differences rests with its assemblage of genes or the genetic makeup. It may be easy to see the differences among different plant species, but it can be difficult to discern differences among individuals within a particular plant species. Researchers use DNA fingerprinting techniques to detect the genetic differences among the individuals.

In a coastal restoration context, diversity of plant species is as important as genetic diversity within a plant species. Smooth cordgrass (*Spartina alterniflora*) is the most important native plant species of the coastal marshes of Louisiana. In addition, several other plant species such as black mangrove (*Avicennia germinans*), marshhay cordgrass (*Spartina patens*), salt grass (*Distichlis spicata*), big cordgrass (*Spartina cynosuroides*), California bulrush (*Schoenoplectus californicus*), seashore paspalum (*Paspalum vaginatum*), bitter panicum (*Panicum amarum*), sea oats (*Uniola paniculata*) and several woody plant species occupy different niches in marsh environments depending on salinity, elevation and other factors.

In newly created or eroded marshes, coastal restoration managers should choose a number of plant species adapted to a particular marsh environment. Increasing the number of diverse genotypes within a particular plant species will enable the vegetation to survive stressors in the long term and establish genetically diverse populations similar to that of native populations in a nondisturbed environment.

Currently, there is little diversity among wetland plant varieties released for wetland restoration activities. For example, in the case of smooth cordgrass, Vermilion is the only released material, and Pelican is the sole black mangrove selection released by the Natural Resources Conservation Service. This lack of quantity and diversity of released plant materials for coastal restoration and reclamation project dictates the urgent need for the development of improved wetland plant materials.

The more genetic diversity a population contains, the greater are its chances to adapt and survive in dynamic marsh environments. Genetic diversity provides a sort of insurance against complete destruction of plant populations in the event of natural disaster. In extreme cases, low genetic diversity may lead to complete elimination of some plant species resulting in loss of overall biological diversity. In the summer of 2000, a "brown marsh event" was noticed in a large expanse of Louisiana marshes. (See page 8.) All *S. alterniflora* vegetation was destroyed while the black mangrove population stayed green and intact. This clearly indicates that plant diversity is immensely beneficial for the overall health of the coastal ecosystem. Using a single variety of smooth cordgrass, such as Vermilion, over large restoration plantings leads to genetic vulnerability.

The best way to increase genetic diversity is to develop and release a suite of improved plant materials for use in coastal restoration plantings, while ensuring that the individuals perform well and have different origins and genetic backgrounds. LSU AgCenter scientists are actively engaged in conducting the research that will help increase genetic diversity among plants suitable for coastal restoration and wetland reclamation projects.

At present, our focus is on the improvement of three plant species – smooth cordgrass, sea oats and California bulrush. A number of smooth cordgrass selections with improved vigor, tillering, spreading habit, rust resistance and seed set have been identified. California bulrush clones with improved salt tolerance are under development, and sea oats field trials are being conducted to identify sea oats lines adaptable to Louisiana environments. ■

Photo by Prasanta K. Subudhi

Plants for coastal restoration are typically started in greenhouses and grown in pots before they're manually transplanted to wetlands areas. Broadening the genetic makeup of these plants can help sustain diversity in the wild.

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Improved Marsh Plants and Seed-Based Propagation

Herry S. Utomo, Michael D. Materne, Stephen A. Harrison, Prasanta K. Subudhi and Niranjan Baisakh

A large-scale revegetation technique that can restore interior marshes affected by erosion is crucial to successfully reduce of coastal marsh loss in Louisiana. Degradation rates and marsh loss are not uniform in all areas. Accelerated rates of subsidence, canal dredging, a cumulative increase in the area of canals and spoil deposits are major factors contributing to the increase in wetland loss rates. In many cases, marsh losses are highest where saltwater intrudes freshwater marshes and native vegetation is unable to cope. Improved varieties of native marsh plants including vegetatively superior, high seed producing smooth cordgrass (*Spartina alterniflora*) and salt-tolerant California bulrush or bulwhip (*Schoenoplectus californicus*) can help stabilize affected areas and rejuvenate degraded marshes by providing resilient, living structures that hold fragile soils and thrive under brackish and saline conditions.

Photo by Bruce Schultz

Herry Utomo harvests seed heads from bulrush at the LSU AgCenter Rice Research Station in Crowley for further research.

Several key steps are required to develop genetically superior, fertile smooth cordgrass lines. These include establishing foundation plots, DNA fingerprinting identification, evaluating cultural practices and conducting aerial seeding experiments currently funded by the U.S. Department of Agriculture and Louisiana Sea Grant. LSU AgCenter researchers have developed 13 elite lines using various plant sources, including 40 Rice Research Station collections and 126 ecotypes cooperatively collected with the USDA Natural Resources Conservation Service.

These elite lines have been widely tested and have shown superior growth and excellent seed production characteristics as compared to wild types. These seed-producing lines have seed set of 33 percent to 94 percent and germination rates of 53 percent to 90 percent. Wild types have much lower fertility and seed viability. These lines are under preparation for release for commercial production. Small foundation plots for these lines have been maintained at the Rice Station and at the LSU AgCenter's Central Research Station at Baton Rouge.

Planting, Harvesting

Current planting practices in restoration projects are both labor-intensive and costly. Labor requirements for collecting, cultivation and planting container plants range from \$6 to \$8 per container and can easily approach \$2,700 to \$3,500 per acre, depending on planting location. In addition, hand planting across large areas requires site access with equipment and mobility around the site. Using container plants as the only means to restore marshes would leave out a great number of marshes in Louisiana because they simply are inaccessible or too fluid to physically support a ground-based planting operation. In comparison, the seed-based propagation technique will only require a fraction of the cost because with aerial seeding, hundreds of acres can potentially be planted in a day.

Seeds of smooth cordgrass can be obtained by harvesting them from the wild. The amount of seed that can be harvested, however, varies from one year to another depending on seed production and inefficiencies associated with hand harvesting. Because these seeds are gathered from genetically unknown materials, it is difficult to predict germination and performance. Seed production under a managed environment, however, will provide a steady supply of smooth cordgrass seed, and the size of the operation can easily be adjusted to meet the demand.

Herry S. Utomo, Assistant Professor, Rice Research Station, Crowley, La.; Michael D. Materne, Instructor; Stephen A. Harrison, Professor; Prasanta K. Subudhi, Assistant Professor; and Niranjan Baisakh, Postdoctoral Researcher, School of Plant, Environmental & Soil Sciences, LSU AgCenter, Baton Rouge, La.


Photo by Herry S. Utomo

Plantlets grown from callus culture in Petri dishes eventually can be transplanted to produce whole plants for coastal restoration.

Because genetic materials to produce seed have gone through extensive testing, the performance of the resulting smooth cordgrass population will be more predictable than that of the seeds collected from the wild.

Alternative Crop

Smooth cordgrass could be an alternative agricultural crop in some areas. This plant has the ability to tolerate a wide range of salinities, from sea strength to freshwater. Populations of smooth cordgrass have been cultivated and maintained under freshwater conditions at several research institutions for years and have performed consistently well. Because smooth cordgrass can be cultivated in a broad range of salinity environments, it is reasonable to assume that large-scale commercial seed production is probable and could be an adjunct crop to rice production with little modification to existing equipment or land. In addition, because of increasing salt contamination of inland groundwater, many areas historically used for rice production have been abandoned, thus providing opportunity for smooth cordgrass production as an alternative crop.

California Bulrush

Native to Louisiana, California bulrush is a perennial, deep-water plant species with an extensive network of rhizomes that form dense colonies. California bulrush can provide a natural barrier by dissipating wave energy to provide calmer environments, which enhance the establishment of other vegetation along shorelines. California bulrush can be used to stabilize newly created marshes and terraces and rehabilitate disturbed sites. Its seed and above-ground structure provide favorable habitat for wildlife, including some endangered species. The potential of California bulrush for erosion control is limited by the fact that it is a freshwater marsh plant that can only tolerate salt concentrations of up 6 parts per thousand. Greater salt tolerance in California bulrush will increase its role in preserving and restoring salt marshes.

In cooperation with the Natural Resources Conservation Service's Plant Materials Program, 48 bulrush ecotypes that demonstrated higher than normal salt tolerances were collected from marshes across Louisiana. These ecotypes were evaluated in replicated field trials at the Rice Station in 2004 and 2005. Nine promising lines with good spreadability, stem density, biomass accumulation and seed production were selected for multi-location trials in 2006 at Cameron, Pointe Aux Chene and Avoca Island. Greenhouse screening to determine the salt-tolerance level among these ecotypes was also carried out in the same years. After exposure in a salt concentration of 12 parts per thousand in continuous flooding for six months, eight plant lines were recovered, increased in the greenhouse and included in the replicated multi-location trials together with the original nine lines.

In an attempt to further improve salt-tolerance, parts of actively growing flowers from one of the most tolerant lines were used to produce callus cultures on media containing growth regulators. This produced millions of break-free individual cells. Under appropriate laboratory conditions, these individual cells will be capable of self-regeneration into whole plants. Instead of thousands of acres to grow millions of plants, this approach reduces the task to laboratory-size Petri dishes.

Our cellular selection using millions of cells has yielded 384 lines generally regarded as salt-tolerant. These lines currently are being grown in the greenhouse for further evaluation in the field in coming years. These salt-tolerant mutants are not considered genetically modified and, therefore, will not be subjected to a strict regulation associated with the use of genetically modified organisms. If these plants retain their salt tolerance as they did at the cell level, they will be readily available for use in coastal marsh restoration.

Certification Program

Professionally grown certified seed or plant material is a prerequisite for efficient and successful large-scale revegetation. In addition to being field-inspected, laboratory-tested and approved by professionals, the certified seed label is proof that the seed or plant material has met all of the standards set forth by the regulatory agencies. Establishing a coastal plant certification program would be in the interest of many plant development programs. It would allow interested parties to communicate, exchange information and agree upon quality standards. DNA fingerprinting could be used to identify and maintain genetic purity of cultivated varieties during the certification process. ■

Photo by Herry S. Utomo

Individual plants developed in the laboratory can be grown in small spaces and evaluated for natural variability.

Plant Pathogens and Louisiana's Brown Marsh Syndrome

Photo by Raymond W. Schneider

Raymond W. Schneider, Susan Useman, Irving Mendelssohn and Karen McKee

Louisiana's coastal salt marshes, which are dominated by smooth cordgrass (*Spartina alterniflora*), suffered a catastrophic dieback in 2000. About 110,000 acres of the Barataria-Terrebonne estuarine salt marsh, which is positioned between the Mississippi and Atchafalaya rivers in south central Louisiana and covers approximately 390,000 acres, were severely damaged. Of those acres, at least 17,000, or about 4 percent, converted from dense vegetation to open mud flats with little or no vegetation. About 150,000 acres are considered moderately impacted because, even though green marsh can still be seen, the marsh has a significant degree of browning.

This dieback, or brown marsh syndrome as it is now known, is a concern because this highly productive ecosystem serves as habitat for many avian, invertebrate and fish species. These marshlands also serve to mitigate hurricane storm surges and to protect vital oil, natural gas and other industries along the Louisiana coast. Similar diebacks were recently documented in Georgia, Delaware, Connecticut, Massachusetts and other Atlantic seaboard states.

To determine the cause and extent of this dieback in Louisiana, a multidisciplinary, coordinated research effort was undertaken. The exact cause, however, has yet to be determined. Factors such as salinity, drought, high temperatures, rainfall, and soil chemical and physical properties were evaluated as possible causal agents. Conclusions from these studies can be viewed at www.brownmarsh.net.

Plant pathologists viewed this catastrophic event as possibly being caused in part by one or more plant pathogens with the expectation that there had been an interaction between unknown pathogens and stressful conditions, such as salinity and drought. Such conditions may have caused the plants to become susceptible to infection by weak pathogens that normally would not cause disease.

> About 110,000 acres of the Barataria-Terrebonne estuarine salt marsh were severely damaged in 2000.

There are examples of similar diebacks in the plant pathology scientific literature. For example, stalk rot of corn, caused by several *Fusarium* species, can cause severe, rapid and widespread losses when the crop is predisposed to water stress early in the season. In this case the predisposing event may occur many weeks before first symptoms are apparent. Other examples include the jarrah forest decline in Australia and little leaf disease of pine in the southeastern United States. In all of these examples, a predisposing stressor is required for otherwise weak pathogens to cause severe symptoms that ultimately lead to plant death. Furthermore, these pathogens can be readily recovered from apparently healthy plants in which they may exist indefinitely as nonpathogenic parasites.

LSU AgCenter scientists isolated fungi from roots and lower stems of symptomatic and healthy smooth cordgrass and tested them in various ways for pathogenicity. In addition, the as yet unidentified fungus that causes a newly described black leaf spot on smooth cordgrass was included in these tests. Those isolates that caused vascular discoloration, stunting or leaf death were then identified and used in an experimental greenhouse system in which plants were subjected to stressors (drought and high salinity) to determine if predisposition accentuated disease severity. The results showed that these stressors alone did not cause symptoms or plant mortality, but in combination with certain strains of *Fusarium* sp., the entire brown marsh syndrome was reproduced.

At this point, it is not certain that pathogens are involved in every instance of smooth cordgrass dieback. It is clear, however, that these fungi are widespread, and in association with certain predisposing conditions, they can cause symptoms identical to those observed under brown marsh conditions.

The next step in the process of resolving the cause or causes of brown marsh is to conduct a wide-ranging survey to determine the geographic distribution of the suspected pathogenic fungi. Isolates would be recovered from apparently healthy and symptomatic plants, and these isolates would then be tested for pathogenicity under normal and stressful conditions. If the syndrome can be reproduced with a large number of isolates of the same fungus under the stressful conditions that existed in the marsh in 2000, but not under normal conditions, then we would conclude that pathogens played a role in the original catastrophic dieback. ■

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Photo by John Wozniak

Recalcitrance and Dormancy in Smooth Cordgrass Seeds

Marc Alan Cohn and James H. Chappell

Establishing smooth cordgrass from seeds is a potentially economical and efficient means for coastal stabilization. While planting seeds is a straightforward procedure for most crops, smooth cordgrass seeds have two special traits that make this operation difficult. First, the seeds are dormant at harvest, similar to many weed seeds. Second, the seeds are recalcitrant, meaning that they die when dried. Research at the LSU AgCenter's Seed Biology Laboratory is devoted to understanding these two traits and using this information to allow large-scale stand establishment of smooth cordgrass from seeds.

Seed Dormancy

Removing dormancy in smooth cordgrass is easy but time-consuming. Immediately after harvest, the seed heads are stored moist at 40-50 degrees F, or the seeds are submerged in cold water (40 degrees F) for two to six months, depending on the variety. After one of these treatments, seeds germinate readily. It is important to avoid freezing the seeds during moist chilling, however, as this will kill the seeds.

Attempts to shorten or eliminate the need for moist chilling through the use of traditional dormancy-breaking chemicals, such as nitrate and gibberellic acid, have not been successful. This is typical for many plants that require a moist-chilling treatment to break seed dormancy. In the future, new treatments that combine germination stimulants and inhibitors of dormancy-maintaining plant hormones need to be evaluated.

Seed Recalcitrance

In addition to smooth cordgrass, many economically important plants, such as coffee, tea, avocado, mangoes, rubber and many citrus species, have recalcitrant seeds. Recalcitrance not only hampers plant propagation from seeds but also makes the normal conservation of genetic resources more challenging, because unlike most other seeds, recalcitrant seeds cannot be stored dry. As a consequence, seed recalcitrance has been a subject of worldwide research for more than 50 years.

Despite these efforts, no satisfactory solution to the problem has been presented. Several causes are due to elements of experimental design or the properties of the seeds chosen for study. These difficulties exist because, in contrast to smooth cordgrass, most recalcitrant-seed species do not have dormant seeds. Some of these seeds (for example, several species of mangroves) actually germinate on the mother plant and are shed as young seedlings. Therefore, while strong seed dormancy is usually a trait to be avoided in crops, it enhances the ability to study the nature of seed recalcitrance. Furthermore, because most other species with recalcitrant seeds germinate quickly and the seed supply is limited to a short time just after harvest, the physiological characteristics of the seeds as they are dried have not been studied in detail at the molecular level. Since smooth cordgrass seeds are dormant, however, research on recalcitrance can be conducted throughout the year.

Smooth cordgrass seeds have unique characteristics that make them an attractive model in which to study seed recalcitrance. Along with being able to conduct research throughout the year due to dormancy, the storage of the moist seeds at low temperature reduces metabolism. In addition, the seeds are small and easy to handle for experimentation. Because other types of cordgrass, such as *Spartina pectinata* (prairie cordgrass), produce conventional seeds that remain alive after drying, drying experiments with both smooth cordgrass and prairie cordgrass allow comparison between the normal responses to drying and those that cause seed death.

Because death due to recalcitrance has been studied for some time, our first approach was to confirm if any existing hypotheses for seed death were correct. Past experiments in other laboratories have suggested recalcitrant seeds die because of biochemical or physical causes. We first chose to re-examine the biochemical processes. One of the dominant ideas in the scientific literature is that recalcitrant seed death is caused by lipid oxidation (a mild form of what occurs when butter turns rancid), which destroys the plant cell membranes during drying. Three independent physiological and biochemical procedures, however, show that lipid oxidation is not the cause of seed death. Previous conclusions to this effect were either due to artifacts of the biochemical methods used or because the results were obtained from using non-dormant seeds.

Nonetheless, these experiments did show that the chemical antioxidants (substances such as vitamin C) in recalcitrant seeds were severely reduced during drying. This finding prompted the question: Are seed components other than membranes damaged? Preliminary results showed a massive increase in protein oxidation as recalcitrant seeds were dried. Identifying the individual proteins that are damaged in this manner may lead to a way to avoid seed recalcitrance. To this end, we are planning further collaborative research to identify these proteins.

Using the system, with both dormant and non-dormant seeds, and comparing conventional and recalcitrant seeds will permit substantial progress in understanding seed death because of drying. A positive outcome will allow *Spartina alterniflora* plants to be established from seeds on the large scale necessary for coastal restoration efforts, and the ability to conserve other economically important recalcitrant species as seeds will be possible. ■

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4-H'ers Learn To Maneuver Through Marshes

Weeklong Camp Offers Chance To Help Save Coast

Mark Shirley

Since 1989, more than 600 high school 4-H students from across Louisiana have had the unforgettable experience of a week of walking in marsh mud, swatting mosquitoes and watching the sun rise over the wetlands. This sometimes grueling but rewarding experience also etched in their minds the wonder, complexity, value and productivity of Louisiana's coastal environment.

Marsh Maneuvers is an educational program aimed at youth sponsored by the LSU AgCenter in cooperation with the Louisiana Sea Grant College Program and the Louisiana Department of Wildlife and Fisheries. From 1993-2003, the program was held in the Barataria watershed, and the Barataria-Terrebonne National Estuary Program was a major contributor. Beginning in 2004, Marsh Maneuvers moved to Rockefeller Wildlife Refuge in Grand Chenier and in 2006, America's Wetland Campaign became a sponsor for the camps.

With the move to Rockefeller Refuge came a new curriculum that focuses on the marshes of the Chenier Plain ecosystem. Students learn about the biological diversity and complexity of this environment by examining the life cycles and habitat requirements of wetland flora and fauna. They participate in evaluating environmental quality through water testing and examining the hydrology of the watershed basins and the coast. Exercises in natural resource management help the students appreciate the difficulty in balancing social needs and environmental consequences. Some of the activities used to illustrate these concepts include fishing, crabbing, cast netting, water chemistry testing, wildlife observation, seafood processing, boating and policy debates.

In 2006, four weeklong camps were held in July and included students from 16 parishes. Parish participation is rotated annually so students from all 64 Louisiana parishes have an opportunity to attend every three or four years.

The LSU AgCenter and Sea Grant provides two fisheries agents as instructors and two 4-H agents as chaperones for each camp session. The Louisiana Department of Wildlife and Fisheries

Marsh Maneuver students haul clumps of smooth cordgrass for planting along the banks of Bayou Petit Anse near Avery Island for erosion control.

Mark Shirley, Southwest Region Coastal Resources Specialist, Abbeville, La.

Photo by Bruce Schultz

Mark Shirley, wearing the baseball cap, working with Marsh Maneuver students.

Photo by Bruce Schultz

provides an aquatic education specialist at each camp as well as dormitory facilities and boat transportation. A grant from America's Wetland and the cooperation of the participating agencies allows the camp to be offered without charge.

Kids and Learning

Marsh Maneuvers involves experiential learning that is fun, different, provides new opportunities, piques curiosity and pushes the young people to try things they would not normally try. If given a choice, not many teenagers would rise before dawn to observe the twilight activities of marsh animals. Not many would choose to crawl through the mud to plant marsh grass for erosion control. But with a little coaxing, they did that and much more.

Enthusiasm is another essential element to learning at Marsh Maneuvers. The instructors at camp try to get the students excited about whatever they are doing at the time. Sometimes that takes corny jokes during a lecture. Sometimes it takes a model of the Mississippi River made with M&M's. And sometimes it is a physical challenge like an early-morning 5K run.

The objective of Marsh Maneuvers is not to make biologists of the students. Some students do express interest in pursuing careers in related fields such as marine biology, wildlife management or some aspect of environmental science. Most have other interests, but the camp demonstrates how coastal resources affect the whole state and nation. The par-

Student Comments from Marsh Maneuvers 2006

While at Marsh Maneuvers we learned a lot about the coast, marshes and wetlands, but while learning we also got to interact and help to protect and save our wetlands. – Red River Parish

Learning about all of this stuff will help me understand things going on in Louisiana, and it provides me with the knowledge to inform other people about all that is happening on the Louisiana coast. – Red River Parish

It helped me learn more about coastal Louisiana and how erosion and the hurricanes affect not only the people from this area, but people from all over the world. – Bienville Parish

This Marsh Maneuvers Camp experience really showed me the importance of the state's coastal marsh ecosystem. – Allen Parish

This camp was really informative about coastal erosion and what we can do to prevent it. – Pointe Coupee Parish

Seeing the destruction from Rita up close made it all that more real and it put into perspective just how important the marshlands are for hurricane protection. – West Baton Rouge Parish

It was the opportunity of a lifetime to come down and learn about the ecology of our state. – Richland Parish

I feel like I better understand the marsh now than I did before, and helping plant things to protect it gives me a connection to the marsh that I will never lose. – Richland Parish

Although it was hard to create a plan without a computer or much time, the planning gave us a look into the challenges people who want to fix the coast are facing. – Vermilion Parish

Photos by Bruce Schultz

ticipants see first-hand how and why the functions and values of the coast affect Louisiana's economy and where they live.

Over the years, students have been challenged to address coastal issues during an activity on the last night of camp. Some years they divided into "stakeholder" groups to debate coastal development issues, much as parish governments constantly struggle with. This past summer, the students tackled the challenge of storm protection and coastal restoration. Armed with information they gleaned during the week, they formulated plans for the Calcasieu, Mermentau and Tech-Vermilion watersheds of southwest Louisiana. To their credit, their recommendations closely parallel the plans being formulated by the state's Coastal Protection and Restoration Authority and the U.S. Army Corps of Engineers. The students were able to reason through the effects of levees for flood protection and the impact on fisheries and wildlife habitats. They also understood how subsidence and sea level rise will increase the risk for some communities in the future.

Hali Jeans of DeRidder with an armload of smooth cordgrass.

Marsh Maneuvers Impact

Each camp session starts with the students taking a knowledge assessment test. The test is intentionally hard but serves several purposes. It sets the tone that Marsh Maneuvers is an educational program that covers a wide range of topics. It gets their attention about subjects and recalls concepts they have learned already in school. During activities and lectures, they remember certain questions as those topics are discussed. That helps to record those things in their memory. The last activity of the week is to take the same test again to measure what they learned. Overall, test scores increase about 25 percent compared to the pre test.

The extended effects of the program are more difficult to enumerate. While only 64 students have the opportunity to attend each summer, their enthusiasm for what they do and learn is contagious. Cell phone are buzzing during break time with calls to friends: "guess what I'm doing now…" or "I held an alligator…" or "we planted marsh grass and I had to crawl thru the mud…yeah, it was gross…" Their families get an earful, too, when the students get back home and continue to tell bits and pieces for weeks thereafter.

When school starts again in the fall, students are encouraged to put their knowledge to work by making presentations to their 4-H Club or other groups and writing essays or term papers on coastal topics for class assignments. Many of them do use their Marsh Maneuvers knowledge at school because they let us know or we hear from their 4-H agents or teachers. Students have called or emailed several years later requesting help for college assignments on topics they learned about at camp.

During one of the camps in 2005, a group of science teachers from North Louisiana visited Rockefeller Refuge and heard about the Marsh Maneuvers 4-H program. One of the teachers raised her hand and said she attended Marsh Maneuvers some 10 years previously. She attributed her camp experience with influencing her decision to become a science teacher. Whether or not they are in a related science field, other alumni from the early years still recall fond memories of their coastal visits. ■

Clint Hebert of DeRidder plants marsh grass in the mud while holding an armload of the marsh grass to be planted.

Center Gaining Recognition for Coastal Economics Research

Photo by Sandra Shanklin

Chandeleur Island Lighthouse, 1985

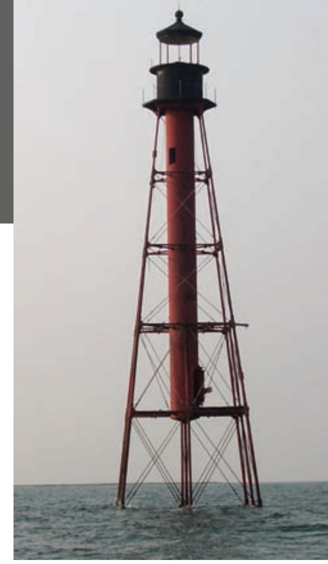


Photo by Rex H. Caffey

Chandeleur Island Lighthouse, July 2005

A newly established cooperative of LSU AgCenter scientists is gaining national recognition in the rapidly expanding field of natural resource economics and policy. The Center for Natural Resource Economics and Policy (CNREP) received final approval from the LSU Board of Supervisors and Louisiana Board of Regents in October 2005.

The history of this center, however, dates back to December 2000, when the Department of Agricultural Economics & Agribusiness became the first LSU AgCenter academic unit to integrate research and extension faculty in the same department.

"We began collaborating on day one," said Rex Caffey, a wetlands and coastal resources economist in the department and director of the center. "We knew we had the basic elements of what could be a unique and valuable center. We just needed a few years to build the critical mass needed to justify a formal proposal."

The spark came in 2003, when Caffey and other faculty in the department described the idea to LSU AgCenter Chancellor William Richardson during a departmental review. "He immediately recognized CNREP for its value, and he insisted that we move forward rapidly to expedite the proposal," Caffey said.

Today, CNREP includes 14 cooperators from four departments, one state agency and five universities. The majority of the cooperators are from the LSU AgCenter's agricultural economics department, including eight faculty members. The other departments are the School of Renewable Natural Resources, the School of the Coast & Environment, Louisiana Sea Grant College and Louisiana Department of Wildlife and Fisheries.

The other universities are Mississippi State University, North Carolina State University, the University of Texas and the University of Georgia.

Since the inception of CNREP, the cooperators have produced more than 325 research and extension publications and 400 professional presentations and have obtained more than $5 million in funding from 37 public and private sources.

"There's a growing recognition at the state and national levels that resource management cannot be limited to the realm of natural science," said CNREP cofounder Richard Kazmierczak, an LSU AgCenter associate professor of agricultural economics. "This is especially true in Louisiana, where there's increasing controversy over the economic valuation and allocation of natural resources, whether they be wetlands, energy, fisheries, wildlife, forests, land or water."

Mike Dunn, an LSU AgCenter associate professor, said CNREP provides a basis for dealing with the economic aspects of resource use and conservation in the areas of forest, wildlife and energy as well as with all aspects of water.

"There's no reason for the LSU AgCenter not to be the premier land-grant organization that deals with the economic and policy aspects of natural resources," Dunn said.

Steve Henning, an LSU AgCenter associate professor, said he expects CNREP to help people become more aware and identify and prioritize research and outreach needs.

"There's an opportunity to get into the process early with data to help make decisions," he said.

Henning said agricultural economists traditionally worked with land management and production economics. Now, most issues have elements of resource policy.

"We're looking at land management with emphasis on resource use and allocation," he said. He said those activities readily translate to other resource issues.

"When policy makers look at the coast, for example, most discussion focuses on physical and technical issues," Henning said. "We can help them consider the financial considerations and the social impacts on people."

Calling it a research cooperative and a center without walls, Caffey said the CNREP's purpose is to contribute to the efficient management and sustainability of Louisiana's natural resources by bringing together social science researchers from diverse program areas, including energy, coastal and inland wetlands, fisheries, forests, wildlife, and soil and water.

"Louisiana is the best place for this sort of research," Caffey said. "It's the terminus of one of the world's largest river systems – a region well-known for its natural productivity."

In recent years, the work of CNREP cooperators has expanded into collaborations with colleagues from around the nation, including faculty at such prominent institutions as Cornell University, Yale University and Woods Hole Oceanographic Institution on Cape Cod, Mass.

■ **Rick Bogren**

CNREP Projects

Benefits and Costs of Wetland Restoration
Costs, Revenue, and Value of Louisiana Oyster Leases
Estimating Land Rights Costs of Restoration Projects
Economic Implications of Fisheries By-catch
Resources Damages from Hurricanes Katrina and Rita
Structure and Management of Northern Gulf Fisheries
Public Acquisition of Coastal Lands for Recreation
Legal Analysis of Property Rights and Compensation
Feasibility Assessment of Rapid Restoration Technologies
Bioeconomics of Biofuel Feedstocks
Economics of Nonpoint-source Pollution Control
Incentives for Private Wetland Stewardship
Economics of Wildlife-associated Recreation
Adoption of Environmental Best Management Practices
Evolution of Conservation Policy in the U.S. Farm Bill

ASSESSING COSTS and BENEFITS of Coastal Restoration Projects

Christine Aust and Rex H. Caffey

More than half a billion dollars has been spent in Louisiana in the past two decades on coastal restoration projects ranging from small community-based efforts to large ecosystem-scale programs. The most significant efforts have come by way of the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA). From its inception in 1990, CWPPRA has authorized more than 155 restoration projects, with 128 of these classified as active – either constructed or in some phase of construction. Most CWPPRA projects are designed to restore or protect coastal wetlands using a combination of vegetative, structural and hydrologic restoration techniques.

In 1998, a group of more than 30 local, state and federal agencies participated in "Coast 2050," a coast-wide reassessment of Louisiana's wetland loss and the efforts under way to address the crisis. They concluded that to merely sustain the state's remaining coastal land would require 77 aggressive restoration projects at an estimated cost of $14 billion. At the current funding level of $35 million - $50 million annually, CWPPRA was providing less than 10 percent of that amount. Several large-scale restoration initiatives were developed in the wake of the Coast 2050 report, though no major programs have been authorized to date.

Christine Aust, Graduate Research Assistant, and Rex H. Caffey, Associate Professor and Director, Center for Natural Resource Economics & Policy, Department of Agricultural Economics & Agribusiness, LSU AgCenter, Baton Rouge, La.

Photo courtesy of U.S. Army Corps of Engineers

Hurricanes can wreak havoc on barrier islands. This photo of Breton Island in Plaquemines Parish was taken in 2001. All of the structure and approximately 80 percent of the land on this island was lost during Hurricane Katrina.

Objectives

In 2004, Congress reauthorized CWPPRA funding for an additional 15 years. At that time, the U.S. Army Corps of Engineers embarked on a reevaluation of the biophysical aspects of the program to better meet restoration needs. Concurrently, an independent economic evaluation of CWPPRA was initiated by the LSU AgCenter's Center for Natural Resource Economics and Policy (CNREP). That evaluation was predicated on the authorizing language in CWPPRA legislation, which states:

> Coastal wetlands restoration projects in Louisiana (will) provide for the long-term conservation of such wetlands and dependent fish and wildlife populations in order of priority, based on the cost-effectiveness of such projects in creating, restoring, protecting, or enhancing coastal wetlands. (Public Law 646 1990, Sec. 3952 1(b))

The primary objective of the CNREP study was to examine the role of

"Barrier island restoration is often cost-prohibitive because it requires working in a remote, high-energy environment," said CNREP director Rex H. Caffey. "Just one individual project can cost more than $100 million dollars to implement, and all of that investment can be lost overnight during one cost-effectiveness in CWPPRA. Specific objectives included 1) documenting how costs and benefits of projects are calculated, 2) examining how specific project attributes affect costs, and 3) assessing the degree to which cost-efficacy has been a determinant of the project selection process.

Results

The CWPPRA program estimates project benefits using the Wetland Value Assessment method. This method is derived from a habitat suitability framework in which a suite of optimal environmental conditions is used to evaluate the forecasted conditions generated from a proposed project. The output of WVA, expressed as dollars per Average Annual Habitat Unit ($/AAHU), has been the primary cost-efficacy standard of measurement upon which CWPPRA dollars have been allocated.

An analysis of authorized active projects was conducted to examine the cost characteristics of specific project attributes. With average costs of $9,461 per AAHU for shoreline projection projects and $10,416 per AAHU for barrier island restoration, these are the most expensive and least efficient of all project types. They were more than double the average cost for nine categories of restoration technology used within the CWPPRA program.

Photo by Rex H. Caffey

Louisiana has approximately 750,000 recreational anglers, more than half of whom fish in coastal areas. Barrier islands provide solitude and prime fishing for those individuals who have access by boat.

Projects with higher costs and less effectiveness appear to have been favored in recent years.

Photo courtesy of U.S. Army Corps of Engineers

hurricane." Caffey and others in CNREP are working to improve the economic and ecological efficiency in which the state allocates its limited funding for coastal restoration, such as at East Island, located in Lower Terrebonne Parish.

Accordingly, the coastal regions and federal sponsors associated with those two project types had a much higher average cost per AAHU. And while slight economies of scale appeared present in the aggregated data for all project types, those efficiencies do not hold up over time. During the first 14 years of the program, average costs for all project types increased from a low of $700/AAHU in 1993 to more than $15,000/AAHU in 2004. Some of this increase can be explained by improved accounting. Project managers assert that benefits were overestimated and cost underestimated in the early years of the program.

To account for any additional factors contributing to this increase, a two-stage assessment was conducted using data collected from all candidate projects nominated to the program from 1991 through 2004. Cost-efficiency was found to be significant and negatively related to project selection over the 14-year span of the program, indicating that managers have been generally mindful of the program's annual budget constraint. This was especially the case during the initial years of the CWPPRA program (1990-1995), when projects were ranked according to cost-efficiency and those with the lowest cost were usually selected for funding. In recent years (1999-2004), however, the least efficient projects (higher costs per AAHU) were found to be significantly and positively related to project selection. In many cases, these less efficient projects were expensive, large-scale barrier island and shoreline protection projects.

Implications

Results of the CNREP study suggest that CWPPRA appears to be moving away from a selection process once highly sensitive to cost-effectiveness. While some of the apparent loss in efficiency may be due to improved cost and benefit accounting, projects with higher costs and less effectiveness appear to have been favored in recent years. CWPPRA has increasingly selected barrier island and shoreline protection projects, despite their relative inefficiency and higher costs compared to other project types. Ultimately, this trend is problematic given the program's fixed annual budget. The findings and recommendations of this research should prove useful in assuring that benefits of Louisiana's coastal restoration and preservation efforts are maximized given the limited amount of funding available. ■

Restoring Wetlands
at New Orleans City Park

Rehabilitation of City Park has included 10,000 plants and thousands of volunteer hours.

Photo by Johnny Morgan

At 1,500 acres, New Orleans City Park stretches two miles from Mid-City to Lake Pontchartrain. From its inception in 1881, this expanse of urban forest and wetland provided the city's residents with a wide variety of recreational activities, including golf, tennis and fishing. One of the 10 largest urban parks in the United States, City Park features 110 acres of lagoons and 105 acres of water in the adjoining Bayou St. John with 11 miles of shoreline.

In 2005, Hurricane Katrina and the subsequent flood put the park in a difficult situation. The storm toppled or severely damaged more than 1,000 trees and inundated the area with up to 10 feet of water from the lake.

Even before the storm, the LSU AgCenter had been at the forefront in helping City Park restore its natural wetland areas and revive the lagoons and bayous for fishing and other activities. After the storm, much of the work had to be redone.

Since its inception, City Park has been effectively self-supporting. It receives barely 2 percent of its operating funds from the state and none from the city. So with 98 percent of its income severely curtailed, the number of park employees has been reduced from 240 to 35, up from a low of 11 just after the storm. The answer to this manpower shortage has been volunteers.

"The AgCenter has been coordinating some of the volunteer efforts at City Park," said Mark Schexnayder, fisheries agent and the AgCenter's Hurricane Katrina recovery coordinator.

Volunteers helped by removing trees blown down by winds and removing non-native trees, primarily Chinese tallow. Non-governmental organizations supplied funds and the use of heavy equipment to help in the process.

Before the storm, an urban fisheries initiative was helping the park improve its fish habitats. Two other fisheries agents – Rusty Gaude and Brian LeBlanc – have helped develop the project, which included restocking fish and installing aeration systems in the City Park lagoons and Bayou St. John.

A master plan was developed by a number of partners, including City Park, the University of New Orleans, the Louisiana Department of Wildlife and Fisheries, the Natural Resources Conservation Service (NRCS) and the AgCenter.

"We were starting to systematically address water quality and shoreline issues," before the hurricane, Schexnayder said. But the project took a different turn after the devastation.

"The shoreline was denuded because of salt water," he said. As a result, "we're planting bulrush, spartina, needle rush, native irises and seaside paspalum."

The plant material came from Nicholls State University, the NRCS facility in Golden Meadow, local iris farms and commercial nurseries, which donated some material and sold other plants at reasonable prices. The Orleans Parish Prison also is contributing by growing plants for transplanting and raising mosquito fish released to help control mosquito populations in the area.

The AgCenter is also coordinating efforts to establish a wetlands plant center at the Pelican Greenhouse in City Park.

"Their greenhouse was under 6-7 feet of water," Schexnayder said. "It's been gutted and re-built with help from volunteer groups from Penn State University, Ohio State University, Michigan State University and Goldman Sachs."

Other volunteers came from a variety of sources, including Common Ground, a community-initiated volunteer organization in New Orleans, and Operation Blessing, an international humanitarian organization based in Virginia Beach, Va.

"We also received grants from Master Gardeners from across the country, Goldman Sachs and Bayou Land Resource Conservation District," Schexnayder said. "And the Lake Pontchartrain Basin Foundation is a partner."

Schexnayder cited thousands of volunteer hours contributed to rehabilitating the park. He estimates more than 10,000 plants have been planted, with thousands more to go.

Lake Pontchartrain feeds into Bayou St. John, so it's brackish. The bayou subsequently feeds into the City Park lagoons, so the water nearest to the bayou is more saline while the water into the park becomes fresher.

"Bayou St. John and the lagoons are some of the only estuarine-influenced water bodies in a city park in the country," Schexnayder said.

In years past, New Orleans had the oldest freshwater bass rodeo in the country. After some years of falling participation, the rodeo had been coming back with help from the AgCenter and other agencies. To help in the recovery, the Louisiana Department of Wildlife and Fisheries began restocking the lagoons with fish this past fall. Work is also under way to dig a freshwater well being supported by donations from Operation Blessing.

"The freshwater side of the lagoons is fed mostly by rainwater," Schexnayder said. "The well will help to manage water quality in the lagoons to help freshwater fish spawn." The lagoons, which were hand-dug by the Works Progress Administration (WPA) during the Great Depression, average 3 to 5 feet in depth, with nothing deeper than 8 to 10 feet. The number of fish that can live in these waters is based on holding capacity, which is influenced by the amount of food available to them, Schexnayder said.

Plants are important because they take up nutrients and bond them, then release them when they die and decompose. They also offer protective hiding places for young fish. The wetlands experts are trying to re-establish eel grass in Bayou St. John to support a larger fish population. ■ **Rick Bogren**

Volunteers remove downed trees and non-native trees to revive City Park in New Orleans.

Photos by Johnny Morgan

The LSU AgCenter helps coordinate work to restore natural wetland areas and lagoons and bayous at City Park. Mark Schexnayder, LSU AgCenter fisheries agent, is at right.

Bioengineered wave breaks grow oysters help restore coast

Steven G. Hall, Robert Beine, Matthew Campbell and Tyler Ortego

Steven G. Hall, Associate Professor, Department of Biological & Agricultural Engineering; Robert Beine, Director, Department of Agricultural Chemistry, LSU AgCenter, Baton Rouge, La.; Matthew Campbell and Tyler Ortego, former students, Department of Biological & Agricultural Engineering, LSU AgCenter, Baton Rouge, La.

Loss of estuarine habitat in Louisiana, which contains 40 percent of the nation's wetlands, has received national attention because of rapid erosion rates. One way to combat this trend is with engineered rock breakwaters and other heavy engineered structures, which have been placed offshore and onshore in critical areas. Unfortunately, these units are too costly for widespread use. Additionally, the heavy rock breakwaters tend to sink through poorly compacted mud sediments. Lower-density, bioengineered submerged breakwaters, such as oysterbreaks, can help address these issues and have the added benefit of contributing to

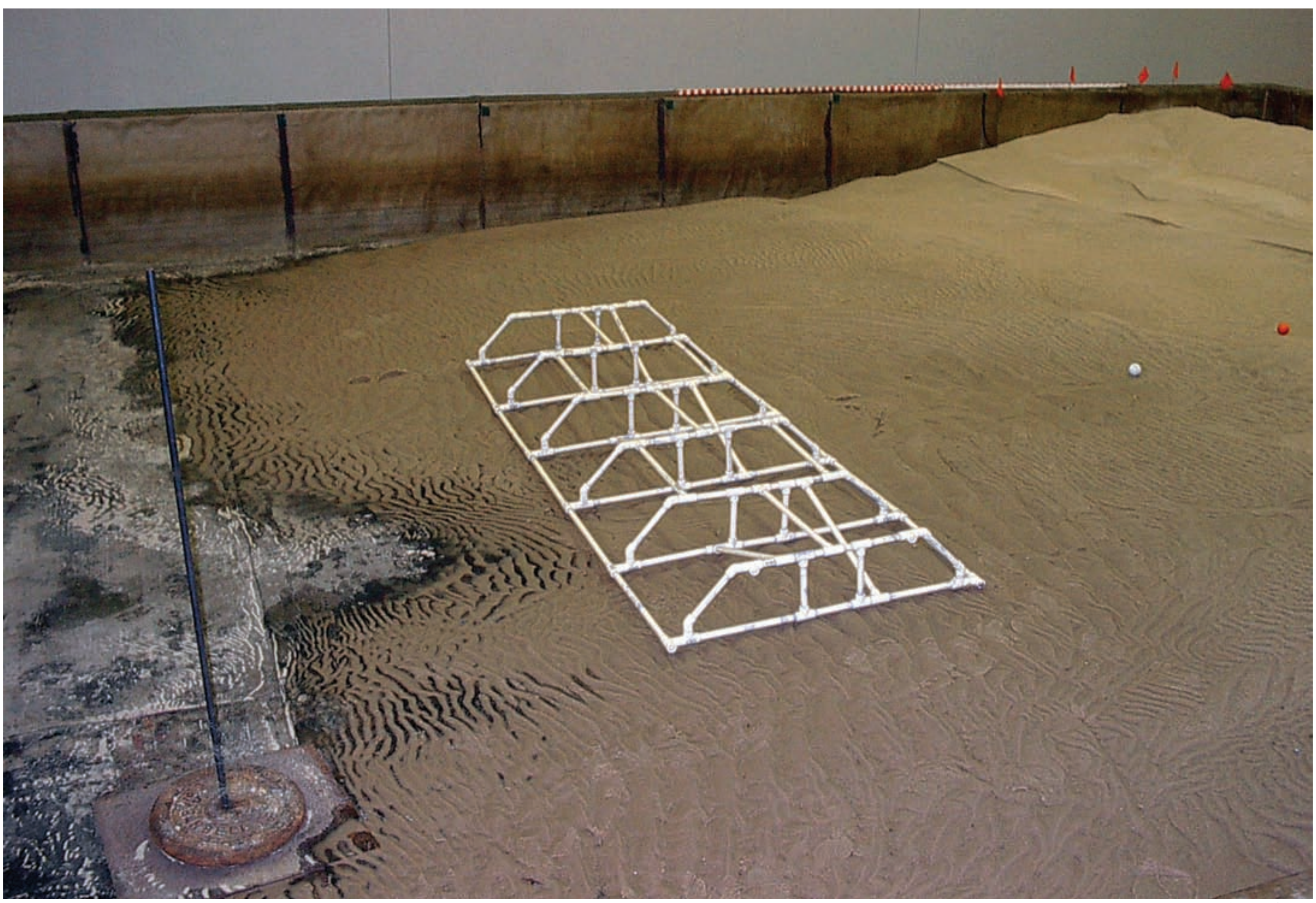


Photo by Steven G. Hall

A model oysterbreak was tested in a wave tank at the LSU Coastal Studies Institute to evaluate its response to wave action. This model is ¼-scale – about 8 feet long by 3 feet wide and 10 inches high.

habitat restoration and oyster production in Gulf Coast areas.

The oysterbreak design allows oysters to form a dense structure that dissipates wave energy, reduces erosion, restores estuarine habitat and enhances or maintains healthy oyster production. This technology uses agricultural byproducts, such as cottonseed, and safe concrete to encourage biologically dominated erosion-reduction reefs. Reef-building animals such as oysters can build mass on structures that encourage their growth. In this process, waterborne material is converted to biomass, which adds to the coastal area. At the same time, reduced wave energy behind the structure tends to cause additional material to be deposited. Recent studies have found a variety of aquatic organisms – including oysters, barnacles, worms, finfish, crabs, snails, algae and plants – increase the biomass on and adjacent to these structures. The increased biomass performs multiple functions, including reducing wave energy and providing habitat for spawn of oysters and other aquatic organisms.

A series of wavebreaks were tested in the LSU Coastal Studies Institute's wavetank, an automated system where ¼-scale models of the oysterbreaks were tested with a series of waves approximating what might be expected in coastal Louisiana. The wave tank experiments concluded that wave transmission through the structure decreased as oyster growth occurred. The predictive model suggests that the oysterbreak can be used in field conditions. It showed that after one year of growth, an oysterbreak 22 yards wide has the capacity to reduce wave energy by 70 percent. These tests showed that oyster growth could significantly reduce wave energy, leading to reduced erosion and possible deposition of material to build land.

Assuming growth rates observed near Grand Isle, La., such reduced energy could be expected in one to three years under favorable growth conditions. One additional advantage of the oysterbreaks is their ability to provide habitat for other estuarine organisms, thus enhancing both the productivity and the protection value of these structures.

Applications include both the use of engineered reefs and engineered materials as cultch material (substances laid on oyster grounds to create a place for oysters to spawn). Engineered reefs are widely accepted for erosion reduction and habitat restoration. These can be made from a variety of materials, including concrete, natural oyster shell and

Photos by Steven G. Hall

A section of a full-size oysterbreak (above) was built and deployed at the LSU oyster hatchery facility at Grand Isle in 2004. The structure is made of "French tube" – expanded and corrugated PVC. The 5-foot-high structure was placed in the water (below) to evaluate its ability as a home for oysters. The area behind the oysterbreak contains a "long-line" system that allows oyster producers to pull up and lower down materials on which oysters live. The area where the oysterbreak was tested allows the structure to be slightly submerged at low tide.

Photos by Steven G. Hall

An early oysterbreak was made of "French tube," expanded and corrugated PVC pipe (above). The material provided habitat for oysters and barnacles as seen in the photo below. Other materials, however, have proved to provide a better place for oysters to live.

agricultural byproducts such as cotton seed. Careful design and placement are necessary for optimal results.

The technology to produce engineered composite cultch material provides a cost-effective alternative to shells, which have a limited supply, and is more environmentally friendly than many other alternatives such as rock or concrete debris. This material can have many different enhanced growth characteristics compared to natural shell, limestone or concrete. First, these materials encourage oyster growth by providing attractants and possible food sources for young oysters, enabling aquaculture and enhancing coastal restoration. Second, oyster growth can be enhanced by appropriate food sources and surfaces in this material, and the oyster growth rates and harvestability can be improved by shape of the structure. Finally, this material can help jump-start growth of other organisms and thus restore or enhance estuarine ecology while providing a substrate for natural oyster fisheries. ■

Photo by John Wozniak

This close-up of a concrete and agricultural byproduct material shows oysters – the largest here about 2 inches long – thrive on this material. This particular substrate had been in the Gulf of Mexico off Grand Isle for about three months when it was removed for the photograph.

Wetlands Soils Lab *helps improve environment*

Manoch Kongchum and Michael D. Materne

Wetlands function as habitats for animals and plants, as filters for water for wildlife and humans, as a sink to mitigate flooding and as recreation areas. People recognize the value of wetlands and try to protect and recover them for many uses. In recent years, researchers and scientists from various fields have been seriously concerned about losses of wetland ecosystems and the surrounding areas.

Wetland soils are known for their high organic matter and as areas for habitats for a variety of plants and animals. Soil characteristics become one of the major determinants of the types and abundance of plant species that grow there. Reliable information on the status and extent of wetland resources in particular areas can be used to determine the nature of soil development and the types of plant and animal communities living in the soil and on its surface. To work efficiently in wetland restoration, the basic soil properties associated with wetlands formation must be clearly understood.

The LSU AgCenter's Coastal Wetlands Soils Characterization Lab – the wet soils lab – was established in 2004 in response to the requirements of universitywide research projects, government agencies, business and industry. The lab provides analytical information on the chemistry and physical properties of soils, particularly from coastal wetlands. The lab receives more than 10,000 soil samples from Louisiana and other states each year. Its testing procedure typically follows the Soil Survey Laboratory Methods and covers a wide array of soil testing services – soil texture, organic matter, bulk density, cation exchange capacity, sodium absorption ratio, exchangeable sodium percentage, acidity and aluminum, electrical conductivity, salinity and soil pH.

In 2005, the U.S. Geological Survey was monitoring the effectiveness of all projects restoring, creating, enhancing and protecting the coastal landscape through the Coastwide Reference Monitoring System Wetland Project. The LSU AgCenter's wet soils lab was chosen to perform soils analyses for these programs.

Generally, clients contact the lab directly or get information off the Web site. They then send soil test request forms and samples to the lab and are charged reasonable fees for the services. Please feel free to contact Manoch Kongchum by phone at (225) 578-1994 or by e-mail at wetsoilslab@agcenter.lsu.edu for further information. ■

Manoch Kongchum, Instructor, and Michael D. Materne, Instructor, School of Plant, Environmental & Soil Sciences, LSU AgCenter, Baton Rouge, La.

OPPORTUNITIES for Nontraditional Agricultural Students in Coastal Wetlands Research

Maud M. Walsh

A growing awareness of the importance of coastal wetlands to Louisiana's economy and environment has attracted students with a variety of interests and backgrounds into undergraduate and graduate programs that have traditionally focused on production agriculture. The devastation of hurricanes Katrina and Rita created a new demand for scientists who could apply their knowledge of plants and soils to assessment and restoration of wetlands damaged by erosion and contamination.

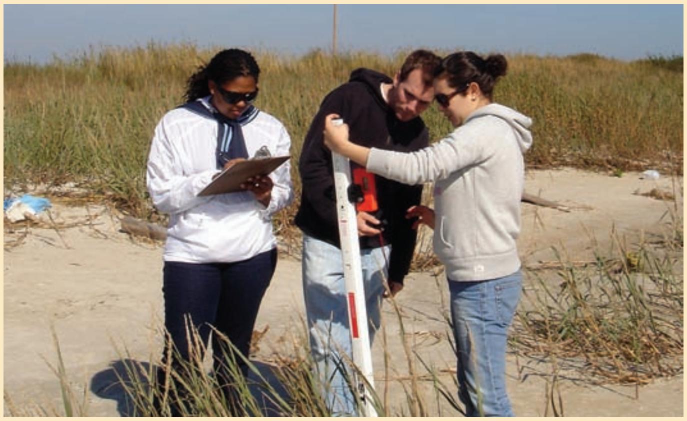
Undergraduate students in the Environmental Management Systems, Forestry, Natural Resource Ecology and Management, and Plant and Soil Systems curricula have the opportunity to enroll in classes that focus on topics and skills related to coastal wetlands, such as wetland soils and plants, land use planning, coastal zone management and geographic information systems.

Students in an applied ecology class assist in planting woody plant species that may flourish in Louisiana's coastal areas and serve as a food source for migratory songbirds.

Students may work with faculty members to design and conduct their own research projects related to coastal wetlands. For example, a recent project by Environmental Management Systems major Blaine Petite examined the impact of oil production brines on soil quality in a coastal area using soil testing and GIS. Funding for undergraduate projects is available from a number of sources, including the LSU College of Agriculture, the Louisiana Sea Grant Undergraduate Research Opportunities Program, and the Coastal Restoration and Enhancement through Science and Technology program.

Coastal wetlands protection and restoration projects require an interdisciplinary approach and therefore provide opportunities for graduate student research in many traditional agricultural disciplines, including forestry, soil science and plant breeding. The Forested Wetlands Research Lab in the School of Renewable Natural Resources examines cypress-tupelo environments using remote sensing. The coastal plants program in the School of Plant, Environmental & Soil Sciences combines crop breeding approaches with molecular genetic techniques to develop plants that can effectively and economically restore coastal dunes and wetlands.

Photos by Maud M. Walsh



Allison Gamble, William Leonards and Sophie Levy measure elevations at Holly Beach.

Current graduate projects include micropropagation of sea oats for coastal dune plantings and optimization of planting smooth cordgrass on terraces constructed for coastal restoration. Graduate students in the Soils and Environmental Program in the School of Plant, Environmental & Soil Sciences are involved in research related to the assessment and mitigation of contamination that threatens coastal wetlands. A recent Ph.D. project focused on the feasibility of using plants to extract arsenic from contaminated soil.

The preservation and restoration of Louisiana's coastal wetlands is critical for Louisiana's future. The LSU AgCenter and the College of Agriculture are preparing undergraduate and graduate students to contribute to this effort. ■

Graduate student LaShunda Anderson conducts greenhouse studies to investigate fern uptake of arsenic.

Maud M. Walsh, Associate Professor, School of Plant, Environmental & Soil Sciences, LSU AgCenter, Baton Rouge, La.

Citrus Research Station Becomes Coastal Area Research Station

Richard L. Parish

Before hurricanes Katrina and Rita, the Citrus Research Station in Port Sulphur was devoted primarily to research on citrus – mainly Satsuma mandarin and navel oranges – with some limited work on commercial vegetables, other fruits and termites. The station was almost completely destroyed by the hurricanes. Most of the buildings were destroyed, and the rest were heavily damaged. Many of the citrus trees died. The major activity at the station since the hurricanes has been rebuilding the infrastructure so productive research can once again be conducted. The station has now been renamed the Coastal Area Research Station to better reflect the expanded research emphasis planned.

The primary research envisioned for the station is developing and evaluating salt-tolerant coastal plants. These plants have been demonstrated to be capable of growing in brackish water and are quite effective at stabilizing eroding shorelines and marsh areas. Although coastal stabilization has long been recognized as important to Louisiana, the 2005 hurricanes revived interest in and support for research on coastal plants. The LSU AgCenter has been working with salt-tolerant coastal plants for more than 20 years at other sites, but the Coastal Area Research Station is an excellent site to expand this work. The ground is low (elevation of about 0.0-2.0 feet above sea level), the soil has high salt content, and water from the Mississippi River is readily available for irrigation and for filling ponds. Plans are complete for a series of eight ponds, totaling five acres of water area. These ponds are being constructed by station staff using station equipment. Elevated artificial sand dunes, a shade house and a can yard to support expanded work in coastal plants are planned.

Research on Formosan subterranean termites was under way at the station before the 2005 hurricanes and has been expanded since. This station provides an excellent site for this research since the station was already infested with Formosan termites and is isolated. Citrus work will continue at the Coastal Area Research Station but on a smaller scale. The first project proposed is a study of subsurface drainage to reduce the water table and reduce the salt content in the soil under rows of citrus trees. The drainage work may be complemented by flushing and leaching with either fresh water or river water.

The station also will continue to support research projects initiated by other faculty from the LSU AgCenter. Research in 2006 included soybean sentinel plots to detect Asian soybean rust and a trial of ornamental sweet potatoes.

The specific emphasis of the Coastal Area Research Station may be changing, but the goal of providing useful research information to the people of Louisiana and specifically to Plaquemines Parish and other coastal areas remains the same. ■

Richard L. Parish, Resident Coordinator, Coastal Area Research Station, LSU AgCenter, Port Sulphur, La.

Youth Wetlands Week

(Continued from page 2)

ministered by the Louisiana Department of Natural Resources. This first year took about $350,000 of the grant to cover the cost of developing, printing and distributing the lesson plans and teaching materials.

"The goal is that more people understand the critical importance of upland and coastal wetlands and the need to prevent further loss," Castille said. "By targeting young people, our efforts will have a longer-term impact."

4-H agents across the state were in charge of recruiting the schools to participate. These agents, along with 18 members of AmeriCorps stationed in Louisiana, also helped with the teaching and carrying out the outdoor projects, Castille said.

"We were able to recruit a graduate student and former middle school teacher, Kathryn Fontenot, to develop lesson plans for about six hours of instruction aimed at 7th and 8th graders and high school environmental science classes," Castille said. "It was important that we have the support of our teachers, not only in development but also in implementation, delivery and evaluation."

"We appreciate the efforts of the LSU AgCenter in planning and developing the 2007 Youth Wetlands Week," said Scott Norton, a director with the Louisiana Department of Education, one of the partners in this project. "Louisiana is one of the few states that includes environmental science in its content standards."

Other cooperators include America's Wetland Campaign, the Barataria-Terrebonne National Estuary Program and the Lieutenant Governor's Office.

Youth Wetlands Week in 2008 and 2009 will be targeted at more grade levels and more schools, Castille said.

"We hope this will continue to be part of the curriculum in Louisiana schools well beyond these three years," Castille said. "We hope what the students learn will carry into their lifetime, and they will be an integral part of saving this American treasure."

■ **Linda Foster Benedict**

Photo by Bruce Schultz

W.W. Lewis Middle School student Victoria Montgomery, center, sprays water on a model of a community to demonstrate the effects of runoff to her classmates. Such educational activities were conducted in classrooms across Louisiana April 16-20 as schools observed Youth Wetlands Week.

Louisiana Sea Grant seeks Chandeleur photos

Among the tremendous losses resulting from Hurricane Katrina was an old lighthouse that stood for more than a century at the tip of Louisiana's most remote barrier island chain. On the morning of Aug. 29, 2005, the 110-year-old Chandeleur Light folded to the sea after serving as a beacon for generations of boaters, anglers, campers, scientists, historians and naturalists. To many people in the northern Gulf, the light held a particular significance. For some, it was a recreational icon – to others, a reference point for coastal land loss. The Louisiana Sea Grant College Program is soliciting photos of the Chandeleur Island Light for an historical archive. See more photos from the collection on page 29. If you are interested in participating, contact Rex Caffey, Associate Professor and Director, Center for Natural Resource Economics & Policy, Room 179 Ag Administration Bldg., LSU, Baton Rouge, La. 70803. ■

Chandeleur Island Lighthouse, 1945

Chandeleur Island Lighthouse, October 1, 1893

Inside:

■ *Dredge sediment enrichment can help with coastal restoration.* *Page 8*

■ *Efforts are under way for a cost-effective method to reintroduce freshwater floating marsh.* *Page 14*

■ *Plant breeders work to enhance native plants for coastal reclamation.* *Page 18*

■ *4-H'ers learn to "maneuver marsh" during weeklong camps on the coast.* *Page 26*

■ *Volunteers help restore wetlands in New Orleans.* *Page 32*

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